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Majzlik et al.

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(45) **Date of Patent: Dec. 27, 2011**

(54) **METHOD FOR POSITIONING A WIRE USING SENSOR INFORMATION**

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(22) Filed: **May 23, 2011**

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G01V 1/40 (2006.01)
G01V 3/18 (2006.01)

(52) **U.S. Cl.** **702/11**; 702/1; 702/2; 702/5; 702/14; 703/2; 703/10; 367/69; 367/72; 367/73

(58) **Field of Classification Search** 702/1, 2, 702/5, 11, 14; 703/2, 10; 367/69, 72, 73
See application file for complete search history.

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Primary Examiner — Sujoy Kundu
(74) *Attorney, Agent, or Firm* — Buskop Law Group, PC; Wendy Buskop

(57) **ABSTRACT**

A method for positioning a wire having nodes and streamers is provided herein. The wire can be secured to tow lines secured to a floating vessel for detecting near surface geology formations. The method can use in-water sensors deployed proximate to the wire near the tow lines, and a processor with data storage in communication with the in-water sensors. The method can use a data array, a library of data formats, a library of wires, a library of preset limits, and a network. The method can include receiving sensor information, filtering sensor information, verifying filtered signals, constructing and modifying a mathematical model, obtaining a list of coordinates, constructing a real-time display of the wire, identifying a location of at least one streamer, transmitting alarms, creating a trend analysis over time and event-by-event, and creating a log file using the industry standard data formats.

16 Claims, 14 Drawing Sheets

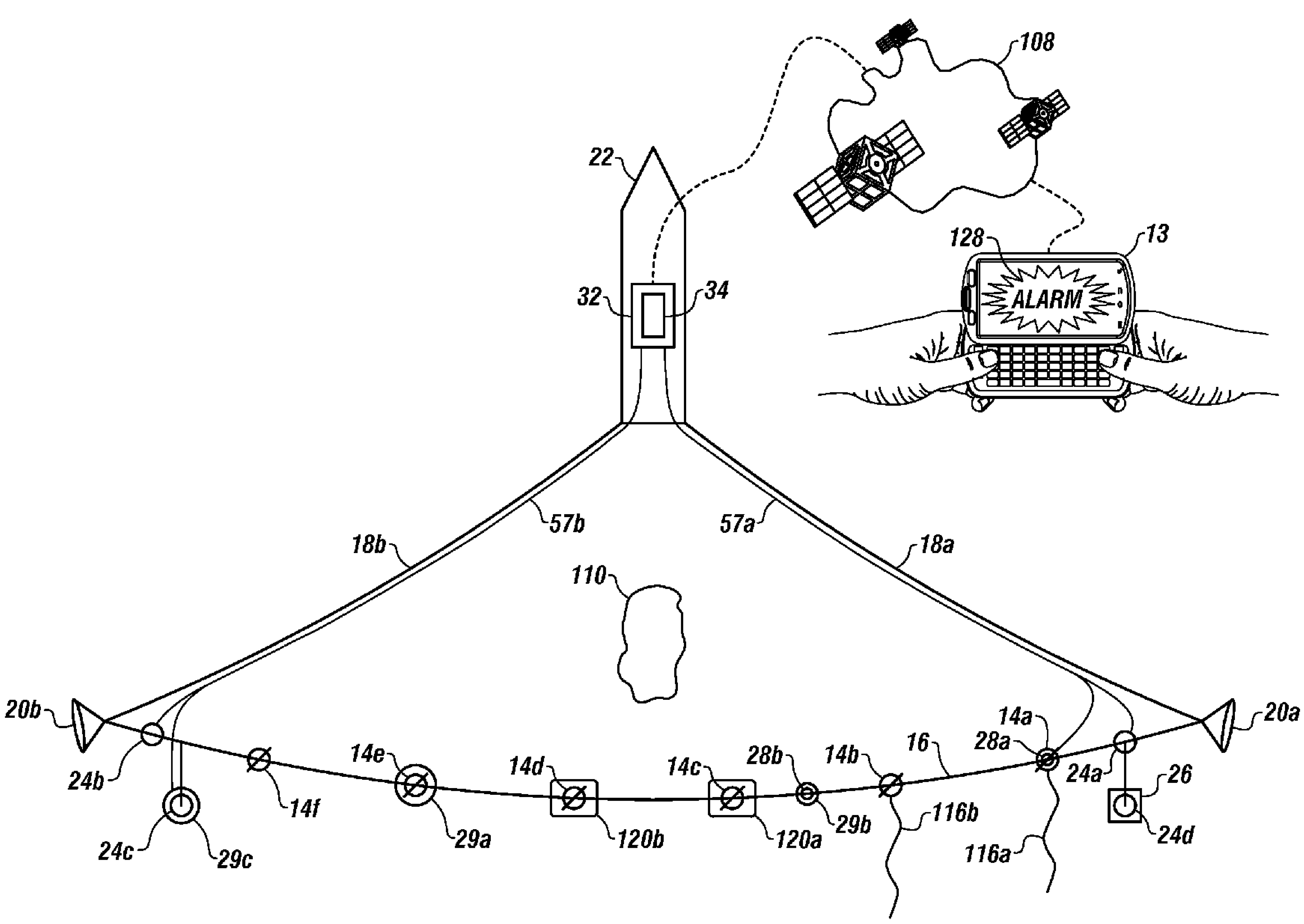


FIGURE 1

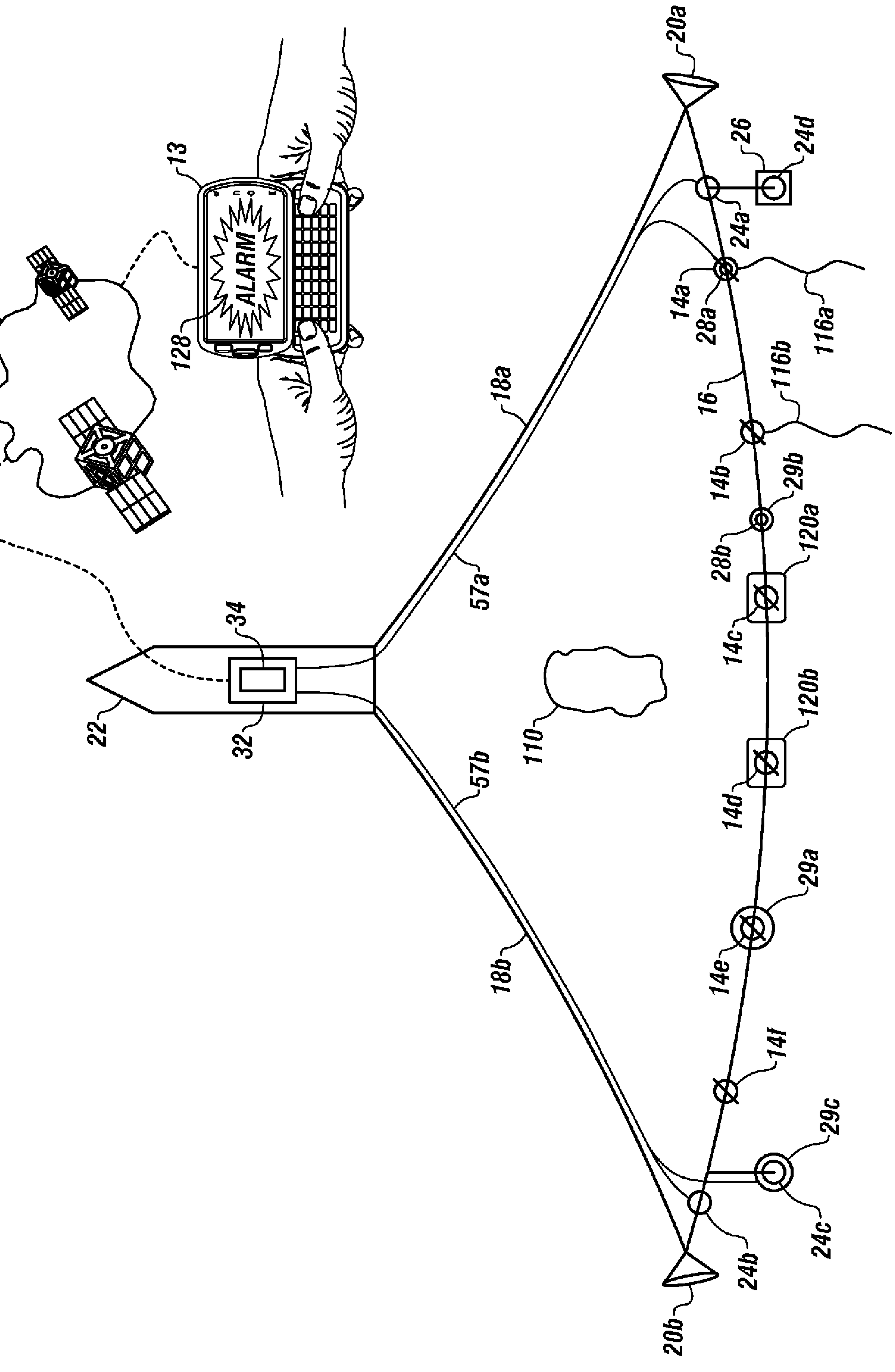

108
13
ALARM
128
20a
26
24d
24a
14a
28a
116a
116b
16
18a
14b
29b
28b
120a
14c
57a
34
32
22
110
57b
120b
14d
29a
14e
18b
14f
29c
24c
24b
20b

FIGURE 2A

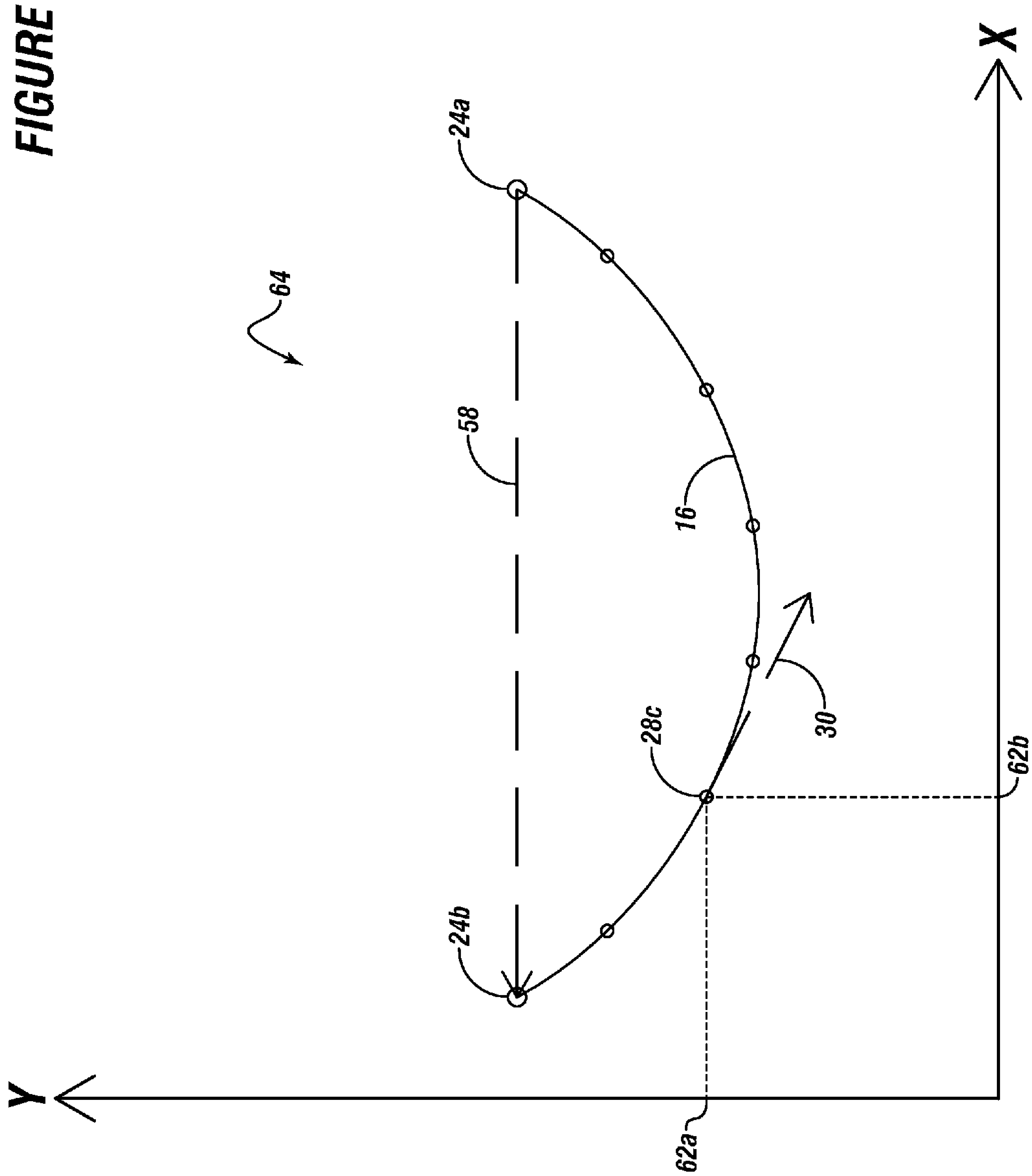


FIGURE 2B

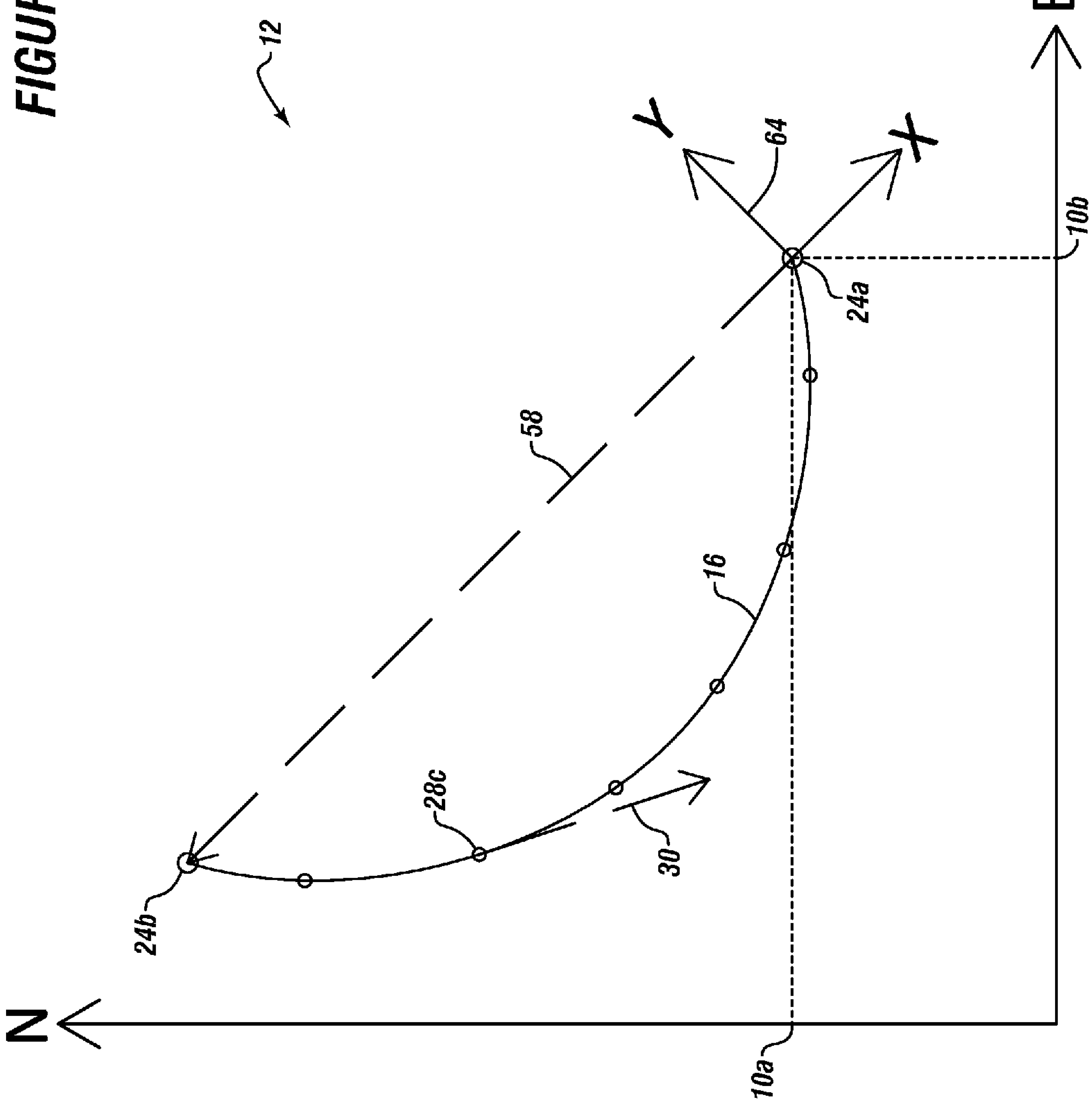


FIGURE 3A

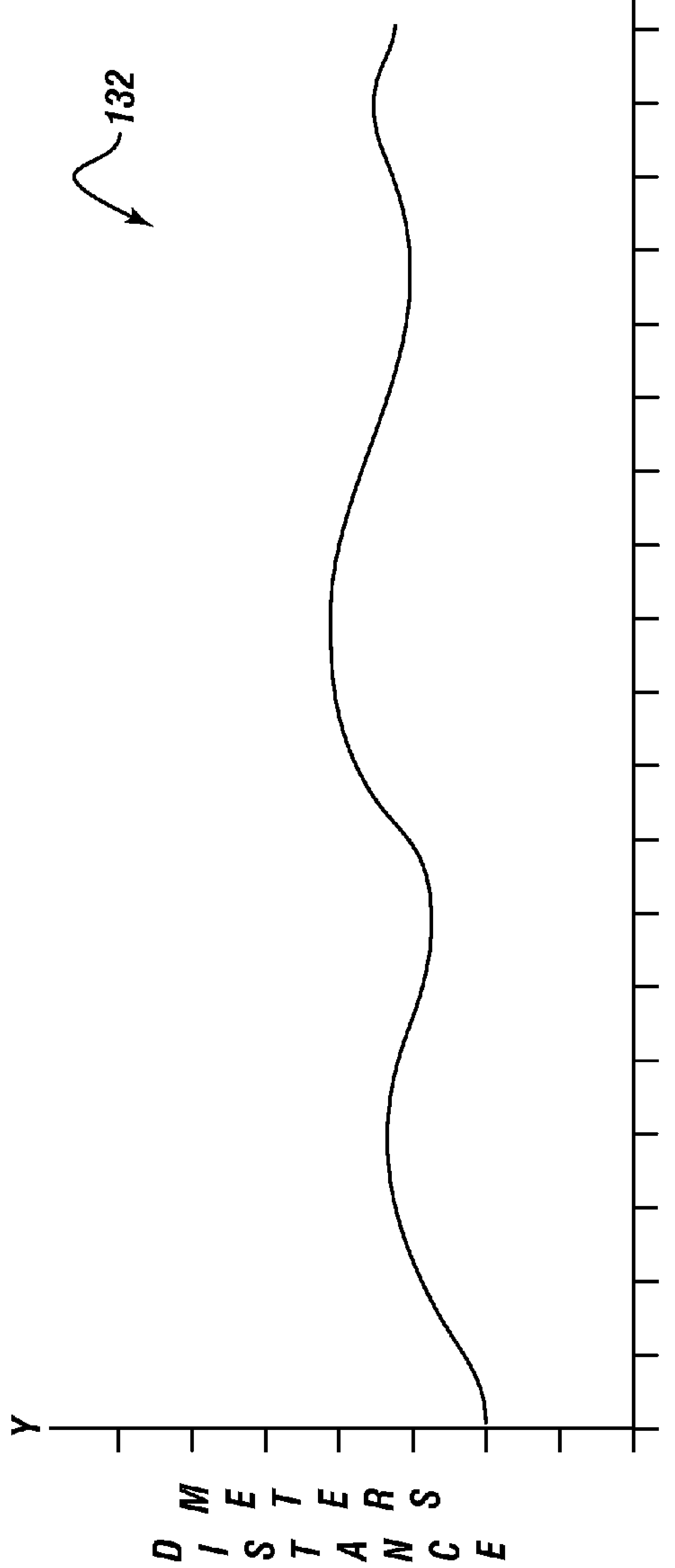


FIGURE 3B

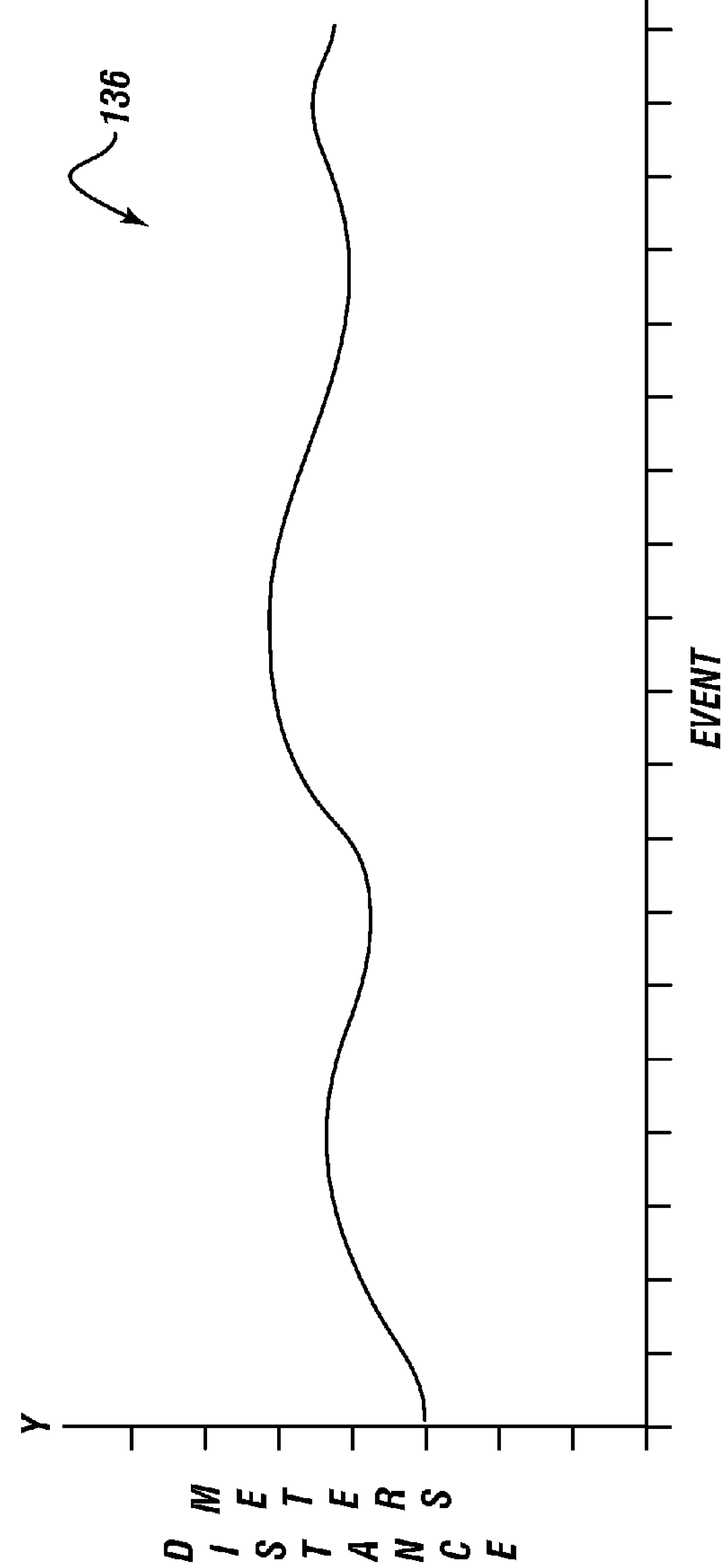


FIGURE 4

140

NODE (143a)	LOCAL X-COORDINATE (143b)	LOCAL Y-COORDINATE (143c)	PROJECTED X-COORDINATE (143d)	PROJECTED Y-COORDINATE (143e)	EVENT (143f)	TIME STEP (143g)
14a	62a	62b	10a	10b	119a	142a
14b	62c	62d	10c	10d	119b	142b
14c	62e	62f	10e	10f	119c	142c

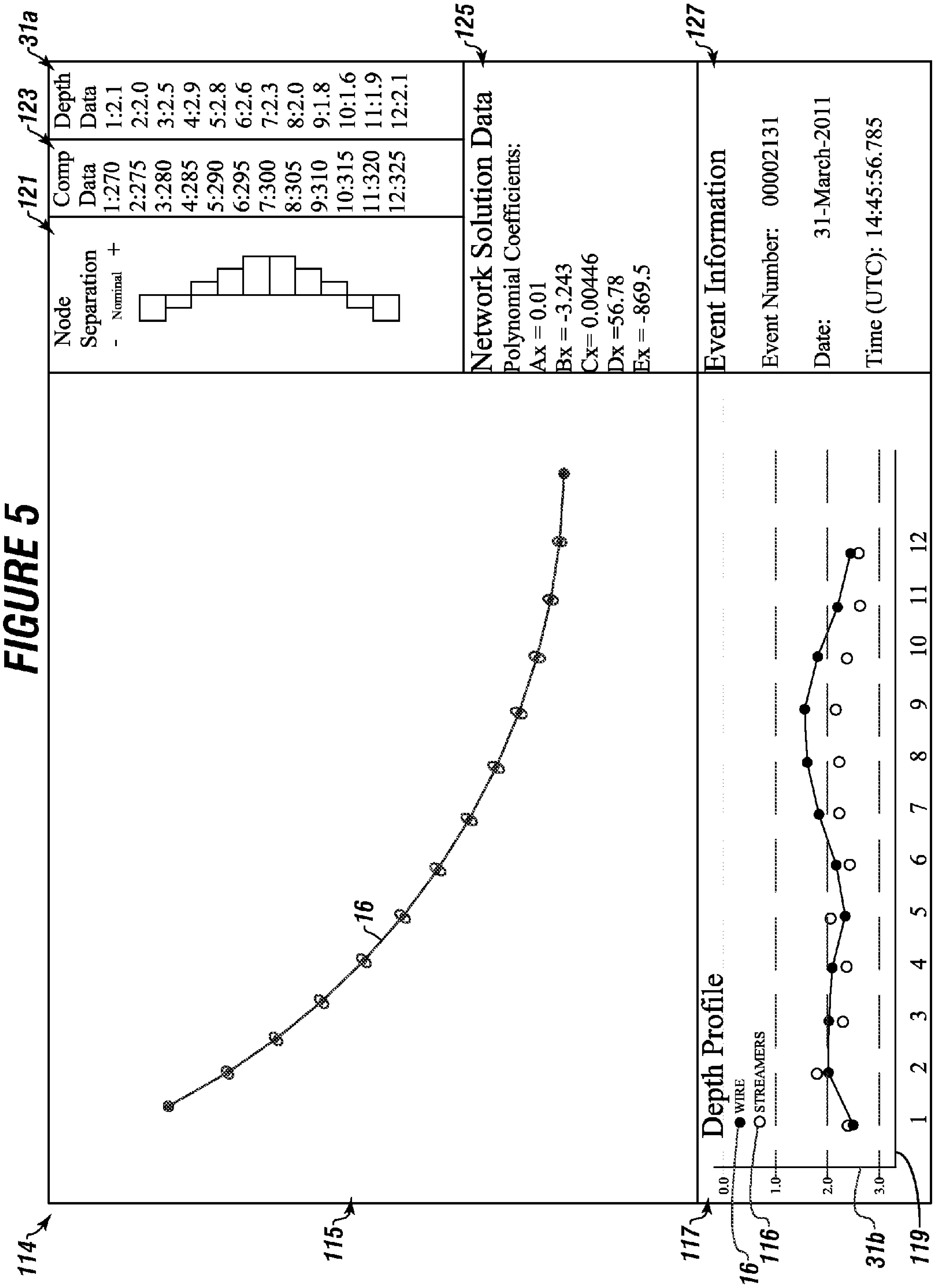

31a
123
121
125
127
Node
Separation
- Nominal +
Comp
Data
1:270
2:275
3:280
4:285
5:290
6:295
7:300
8:305
9:310
10:315
11:320
12:325
Depth
Data
1:2.1
2:2.0
3:2.5
4:2.9
5:2.8
6:2.6
7:2.3
8:2.0
9:1.8
10:1.6
11:1.9
12:2.1
Network Solution Data
Polynomial Coefficients:
Ax = 0.01
Bx = -3.243
Cx= 0.00446
Dx =56.78
Ex = -869.5
Event Information
Event Number: 00002131
Date: 31-March-2011
Time (UTC): 14:45:56.785
16
Depth Profile
WIRE
STREAMERS
0.0
1.0
2.0
3.0
1
2
3
4
5
6
7
8
9
10
11
12
114
115
117
16
116
31b
119

FIGURE 5

FIGURE 6A

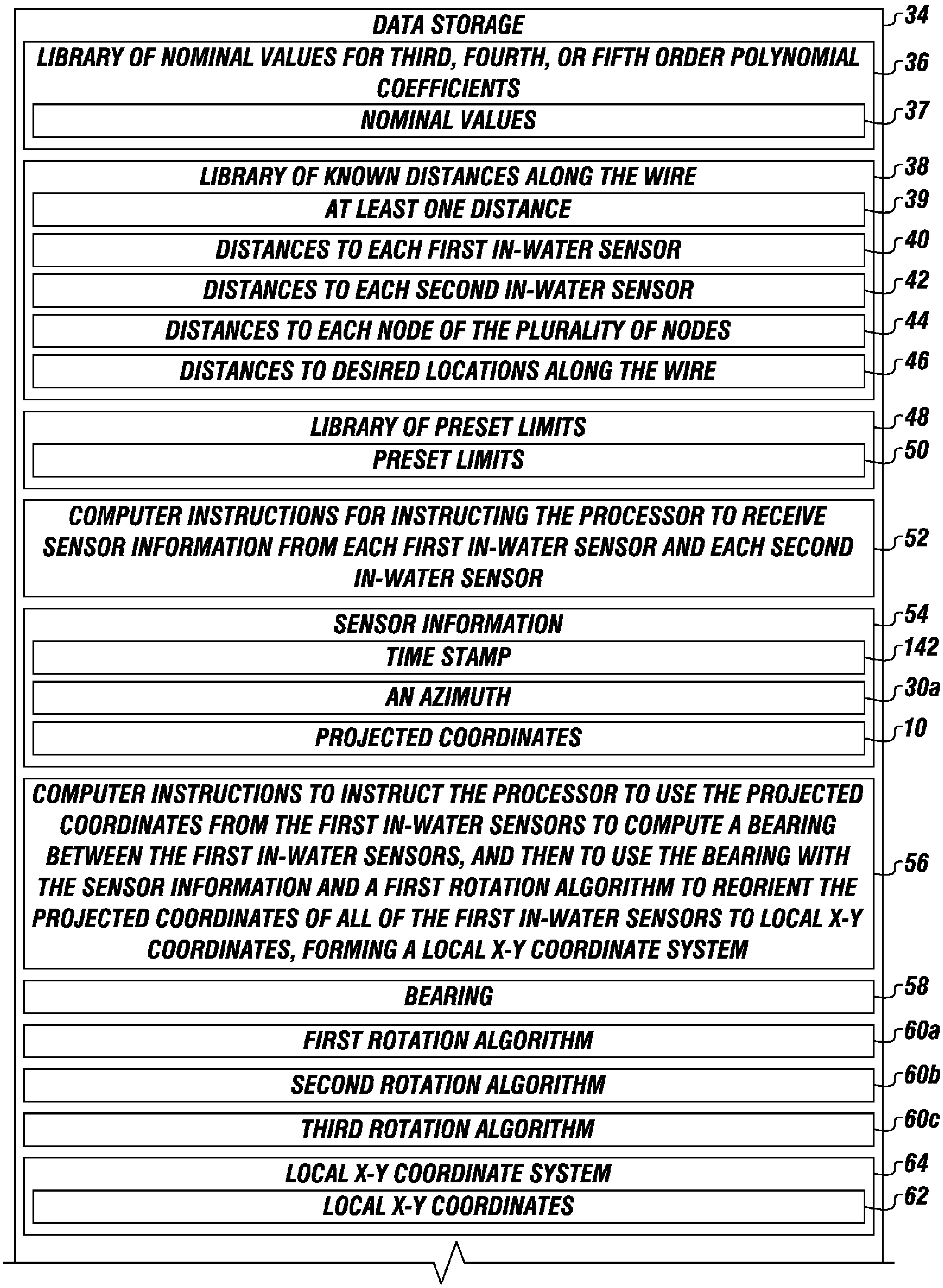

DATA STORAGE
34
LIBRARY OF NOMINAL VALUES FOR THIRD, FOURTH, OR FIFTH ORDER POLYNOMIAL COEFFICIENTS
36
NOMINAL VALUES
37
LIBRARY OF KNOWN DISTANCES ALONG THE WIRE
38
AT LEAST ONE DISTANCE
39
DISTANCES TO EACH FIRST IN-WATER SENSOR
40
DISTANCES TO EACH SECOND IN-WATER SENSOR
42
DISTANCES TO EACH NODE OF THE PLURALITY OF NODES
44
DISTANCES TO DESIRED LOCATIONS ALONG THE WIRE
46
LIBRARY OF PRESET LIMITS
48
PRESET LIMITS
50
COMPUTER INSTRUCTIONS FOR INSTRUCTING THE PROCESSOR TO RECEIVE SENSOR INFORMATION FROM EACH FIRST IN-WATER SENSOR AND EACH SECOND IN-WATER SENSOR
52
SENSOR INFORMATION
54
TIME STAMP
142
AN AZIMUTH
30a
PROJECTED COORDINATES
10
COMPUTER INSTRUCTIONS TO INSTRUCT THE PROCESSOR TO USE THE PROJECTED COORDINATES FROM THE FIRST IN-WATER SENSORS TO COMPUTE A BEARING BETWEEN THE FIRST IN-WATER SENSORS, AND THEN TO USE THE BEARING WITH THE SENSOR INFORMATION AND A FIRST ROTATION ALGORITHM TO REORIENT THE PROJECTED COORDINATES OF ALL OF THE FIRST IN-WATER SENSORS TO LOCAL X-Y COORDINATES, FORMING A LOCAL X-Y COORDINATE SYSTEM
56
BEARING
58
FIRST ROTATION ALGORITHM
60a
SECOND ROTATION ALGORITHM
60b
THIRD ROTATION ALGORITHM
60c
LOCAL X-Y COORDINATE SYSTEM
64
LOCAL X-Y COORDINATES
62

FIGURE 6B

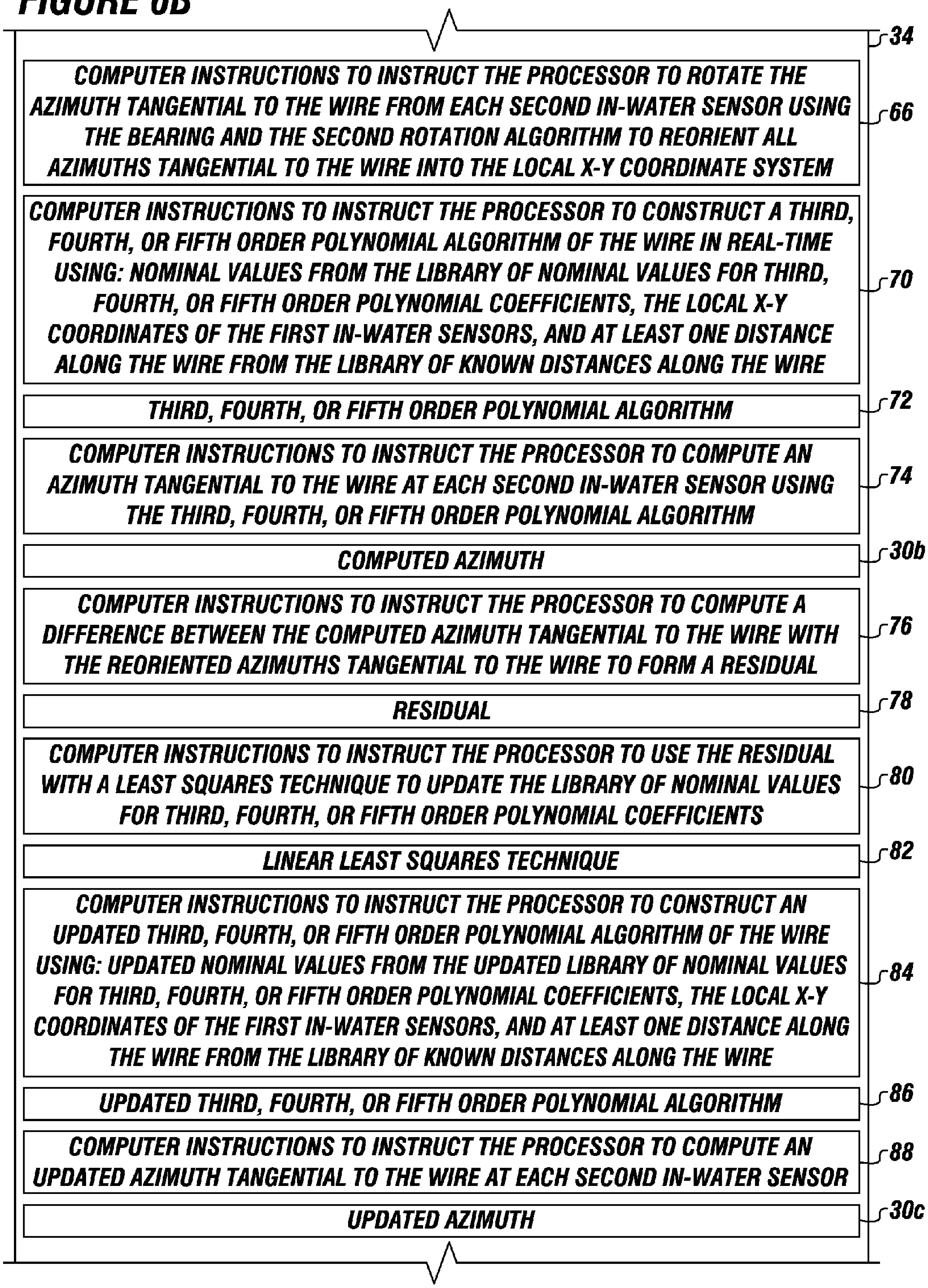
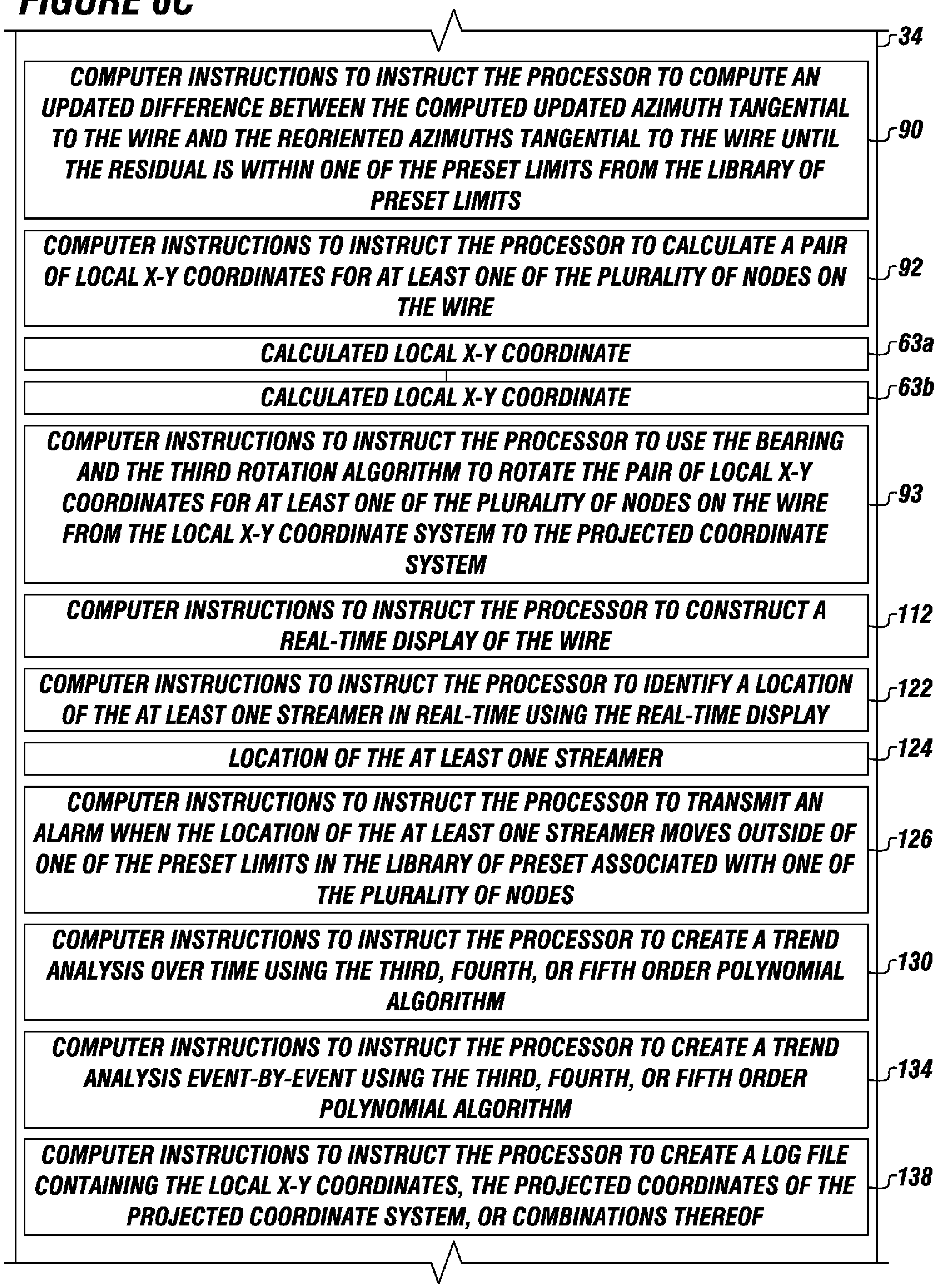

34
COMPUTER INSTRUCTIONS TO INSTRUCT THE PROCESSOR TO ROTATE THE AZIMUTH TANGENTIAL TO THE WIRE FROM EACH SECOND IN-WATER SENSOR USING THE BEARING AND THE SECOND ROTATION ALGORITHM TO REORIENT ALL AZIMUTHS TANGENTIAL TO THE WIRE INTO THE LOCAL X-Y COORDINATE SYSTEM
66
COMPUTER INSTRUCTIONS TO INSTRUCT THE PROCESSOR TO CONSTRUCT A THIRD, FOURTH, OR FIFTH ORDER POLYNOMIAL ALGORITHM OF THE WIRE IN REAL-TIME USING: NOMINAL VALUES FROM THE LIBRARY OF NOMINAL VALUES FOR THIRD, FOURTH, OR FIFTH ORDER POLYNOMIAL COEFFICIENTS, THE LOCAL X-Y COORDINATES OF THE FIRST IN-WATER SENSORS, AND AT LEAST ONE DISTANCE ALONG THE WIRE FROM THE LIBRARY OF KNOWN DISTANCES ALONG THE WIRE
70
THIRD, FOURTH, OR FIFTH ORDER POLYNOMIAL ALGORITHM
72
COMPUTER INSTRUCTIONS TO INSTRUCT THE PROCESSOR TO COMPUTE AN AZIMUTH TANGENTIAL TO THE WIRE AT EACH SECOND IN-WATER SENSOR USING THE THIRD, FOURTH, OR FIFTH ORDER POLYNOMIAL ALGORITHM
74
COMPUTED AZIMUTH
30b
COMPUTER INSTRUCTIONS TO INSTRUCT THE PROCESSOR TO COMPUTE A DIFFERENCE BETWEEN THE COMPUTED AZIMUTH TANGENTIAL TO THE WIRE WITH THE REORIENTED AZIMUTHS TANGENTIAL TO THE WIRE TO FORM A RESIDUAL
76
RESIDUAL
78
COMPUTER INSTRUCTIONS TO INSTRUCT THE PROCESSOR TO USE THE RESIDUAL WITH A LEAST SQUARES TECHNIQUE TO UPDATE THE LIBRARY OF NOMINAL VALUES FOR THIRD, FOURTH, OR FIFTH ORDER POLYNOMIAL COEFFICIENTS
80
LINEAR LEAST SQUARES TECHNIQUE
82
COMPUTER INSTRUCTIONS TO INSTRUCT THE PROCESSOR TO CONSTRUCT AN UPDATED THIRD, FOURTH, OR FIFTH ORDER POLYNOMIAL ALGORITHM OF THE WIRE USING: UPDATED NOMINAL VALUES FROM THE UPDATED LIBRARY OF NOMINAL VALUES FOR THIRD, FOURTH, OR FIFTH ORDER POLYNOMIAL COEFFICIENTS, THE LOCAL X-Y COORDINATES OF THE FIRST IN-WATER SENSORS, AND AT LEAST ONE DISTANCE ALONG THE WIRE FROM THE LIBRARY OF KNOWN DISTANCES ALONG THE WIRE
84
UPDATED THIRD, FOURTH, OR FIFTH ORDER POLYNOMIAL ALGORITHM
86
COMPUTER INSTRUCTIONS TO INSTRUCT THE PROCESSOR TO COMPUTE AN UPDATED AZIMUTH TANGENTIAL TO THE WIRE AT EACH SECOND IN-WATER SENSOR
88
UPDATED AZIMUTH
30c

FIGURE 6C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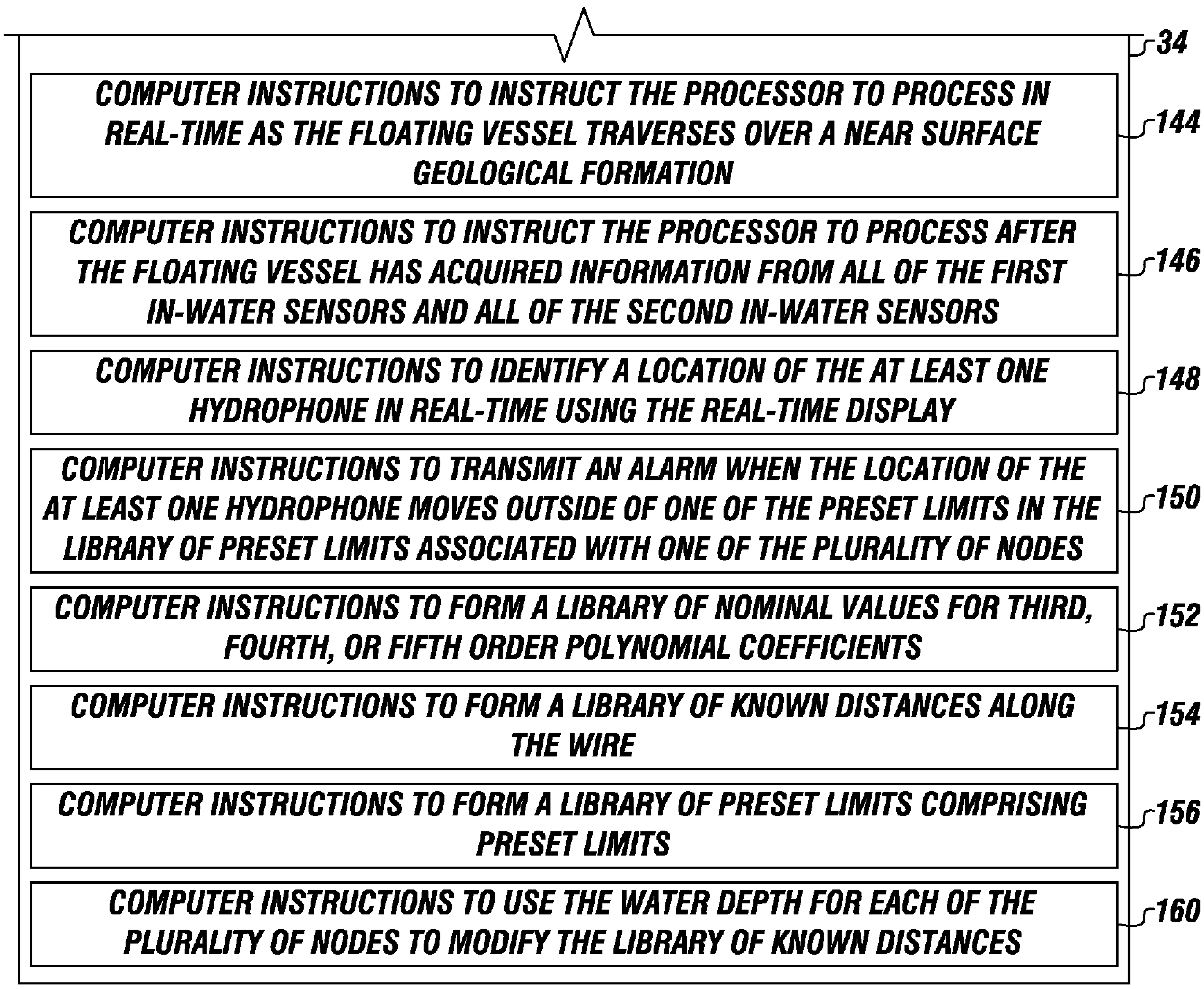
COMPUTER INSTRUCTIONS TO INSTRUCT THE PROCESSOR TO COMPUTE AN UPDATED DIFFERENCE BETWEEN THE COMPUTED UPDATED AZIMUTH TANGENTIAL TO THE WIRE AND THE REORIENTED AZIMUTHS TANGENTIAL TO THE WIRE UNTIL THE RESIDUAL IS WITHIN ONE OF THE PRESET LIMITS FROM THE LIBRARY OF PRESET LIMITS
90
COMPUTER INSTRUCTIONS TO INSTRUCT THE PROCESSOR TO CALCULATE A PAIR OF LOCAL X-Y COORDINATES FOR AT LEAST ONE OF THE PLURALITY OF NODES ON THE WIRE
92
CALCULATED LOCAL X-Y COORDINATE
63a
CALCULATED LOCAL X-Y COORDINATE
63b
COMPUTER INSTRUCTIONS TO INSTRUCT THE PROCESSOR TO USE THE BEARING AND THE THIRD ROTATION ALGORITHM TO ROTATE THE PAIR OF LOCAL X-Y COORDINATES FOR AT LEAST ONE OF THE PLURALITY OF NODES ON THE WIRE FROM THE LOCAL X-Y COORDINATE SYSTEM TO THE PROJECTED COORDINATE SYSTEM
93
COMPUTER INSTRUCTIONS TO INSTRUCT THE PROCESSOR TO CONSTRUCT A REAL-TIME DISPLAY OF THE WIRE
112
COMPUTER INSTRUCTIONS TO INSTRUCT THE PROCESSOR TO IDENTIFY A LOCATION OF THE AT LEAST ONE STREAMER IN REAL-TIME USING THE REAL-TIME DISPLAY
122
LOCATION OF THE AT LEAST ONE STREAMER
124
COMPUTER INSTRUCTIONS TO INSTRUCT THE PROCESSOR TO TRANSMIT AN ALARM WHEN THE LOCATION OF THE AT LEAST ONE STREAMER MOVES OUTSIDE OF ONE OF THE PRESET LIMITS IN THE LIBRARY OF PRESET ASSOCIATED WITH ONE OF THE PLURALITY OF NODES
126
COMPUTER INSTRUCTIONS TO INSTRUCT THE PROCESSOR TO CREATE A TREND ANALYSIS OVER TIME USING THE THIRD, FOURTH, OR FIFTH ORDER POLYNOMIAL ALGORITHM
130
COMPUTER INSTRUCTIONS TO INSTRUCT THE PROCESSOR TO CREATE A TREND ANALYSIS EVENT-BY-EVENT USING THE THIRD, FOURTH, OR FIFTH ORDER POLYNOMIAL ALGORITHM
134
COMPUTER INSTRUCTIONS TO INSTRUCT THE PROCESSOR TO CREATE A LOG FILE CONTAINING THE LOCAL X-Y COORDINATES, THE PROJECTED COORDINATES OF THE PROJECTED COORDINATE SYSTEM, OR COMBINATIONS THEREOF
138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COMPUTER INSTRUCTIONS TO INSTRUCT THE PROCESSOR TO PROCESS IN REAL-TIME AS THE FLOATING VESSEL TRAVERSES OVER A NEAR SURFACE GEOLOGICAL FORMATION
144
COMPUTER INSTRUCTIONS TO INSTRUCT THE PROCESSOR TO PROCESS AFTER THE FLOATING VESSEL HAS ACQUIRED INFORMATION FROM ALL OF THE FIRST IN-WATER SENSORS AND ALL OF THE SECOND IN-WATER SENSORS
146
COMPUTER INSTRUCTIONS TO IDENTIFY A LOCATION OF THE AT LEAST ONE HYDROPHONE IN REAL-TIME USING THE REAL-TIME DISPLAY
148
COMPUTER INSTRUCTIONS TO TRANSMIT AN ALARM WHEN THE LOCATION OF THE AT LEAST ONE HYDROPHONE MOVES OUTSIDE OF ONE OF THE PRESET LIMITS IN THE LIBRARY OF PRESET LIMITS ASSOCIATED WITH ONE OF THE PLURALITY OF NODES
150
COMPUTER INSTRUCTIONS TO FORM A LIBRARY OF NOMINAL VALUES FOR THIRD, FOURTH, OR FIFTH ORDER POLYNOMIAL COEFFICIENTS
152
COMPUTER INSTRUCTIONS TO FORM A LIBRARY OF KNOWN DISTANCES ALONG THE WIRE
154
COMPUTER INSTRUCTIONS TO FORM A LIBRARY OF PRESET LIMITS COMPRISING PRESET LIMITS
156
COMPUTER INSTRUCTIONS TO USE THE WATER DEPTH FOR EACH OF THE PLURALITY OF NODES TO MODIFY THE LIBRARY OF KNOWN DISTANCES
160

FIGURE 6D

FIGURE 7A

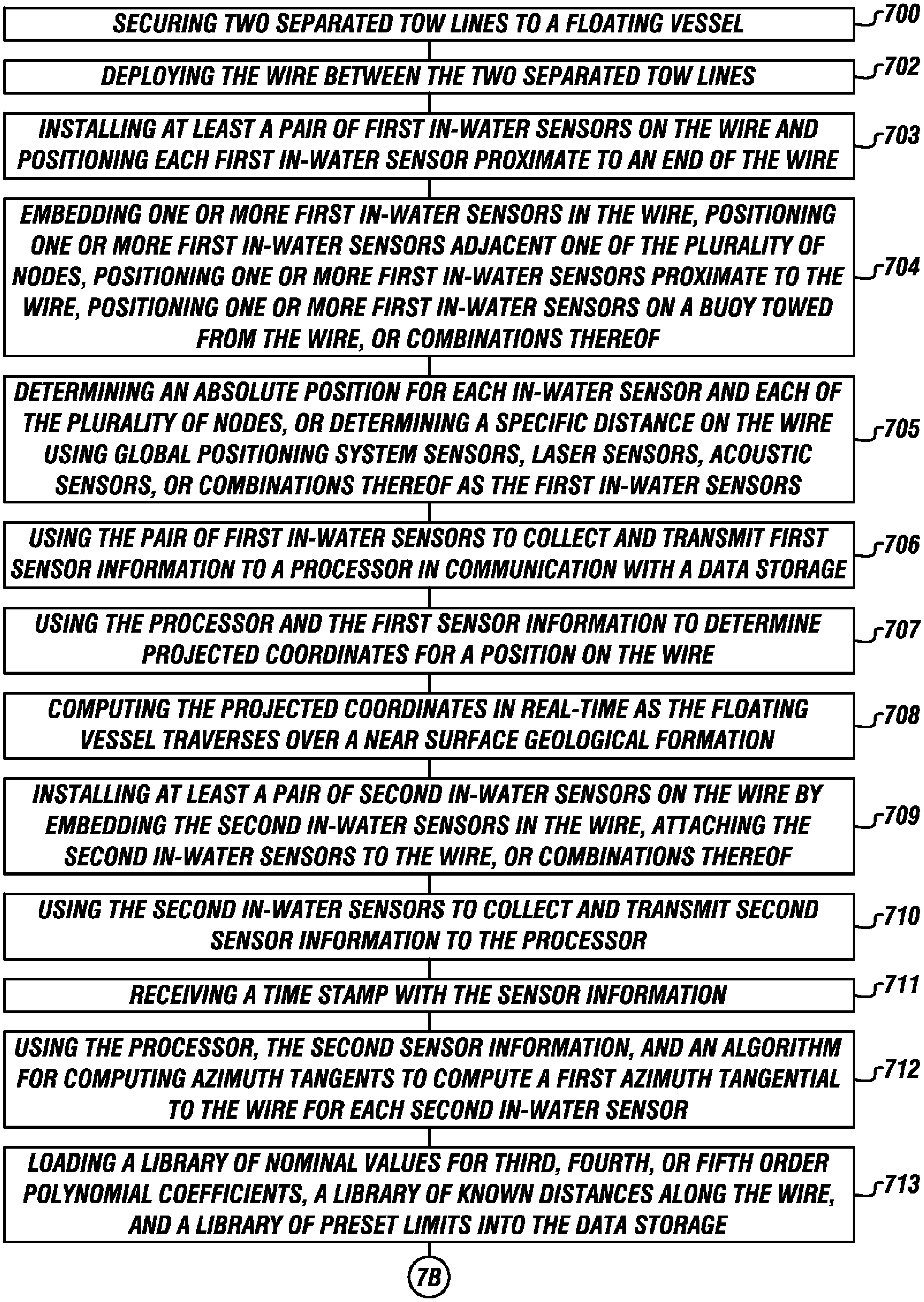

SECURING TWO SEPARATED TOW LINES TO A FLOATING VESSEL
700
DEPLOYING THE WIRE BETWEEN THE TWO SEPARATED TOW LINES
702
INSTALLING AT LEAST A PAIR OF FIRST IN-WATER SENSORS ON THE WIRE AND POSITIONING EACH FIRST IN-WATER SENSOR PROXIMATE TO AN END OF THE WIRE
703
EMBEDDING ONE OR MORE FIRST IN-WATER SENSORS IN THE WIRE, POSITIONING ONE OR MORE FIRST IN-WATER SENSORS ADJACENT ONE OF THE PLURALITY OF NODES, POSITIONING ONE OR MORE FIRST IN-WATER SENSORS PROXIMATE TO THE WIRE, POSITIONING ONE OR MORE FIRST IN-WATER SENSORS ON A BUOY TOWED FROM THE WIRE, OR COMBINATIONS THEREOF
704
DETERMINING AN ABSOLUTE POSITION FOR EACH IN-WATER SENSOR AND EACH OF THE PLURALITY OF NODES, OR DETERMINING A SPECIFIC DISTANCE ON THE WIRE USING GLOBAL POSITIONING SYSTEM SENSORS, LASER SENSORS, ACOUSTIC SENSORS, OR COMBINATIONS THEREOF AS THE FIRST IN-WATER SENSORS
705
USING THE PAIR OF FIRST IN-WATER SENSORS TO COLLECT AND TRANSMIT FIRST SENSOR INFORMATION TO A PROCESSOR IN COMMUNICATION WITH A DATA STORAGE
706
USING THE PROCESSOR AND THE FIRST SENSOR INFORMATION TO DETERMINE PROJECTED COORDINATES FOR A POSITION ON THE WIRE
707
COMPUTING THE PROJECTED COORDINATES IN REAL-TIME AS THE FLOATING VESSEL TRAVERSES OVER A NEAR SURFACE GEOLOGICAL FORMATION
708
INSTALLING AT LEAST A PAIR OF SECOND IN-WATER SENSORS ON THE WIRE BY EMBEDDING THE SECOND IN-WATER SENSORS IN THE WIRE, ATTACHING THE SECOND IN-WATER SENSORS TO THE WIRE, OR COMBINATIONS THEREOF
709
USING THE SECOND IN-WATER SENSORS TO COLLECT AND TRANSMIT SECOND SENSOR INFORMATION TO THE PROCESSOR
710
RECEIVING A TIME STAMP WITH THE SENSOR INFORMATION
711
USING THE PROCESSOR, THE SECOND SENSOR INFORMATION, AND AN ALGORITHM FOR COMPUTING AZIMUTH TANGENTS TO COMPUTE A FIRST AZIMUTH TANGENTIAL TO THE WIRE FOR EACH SECOND IN-WATER SENSOR
712
LOADING A LIBRARY OF NOMINAL VALUES FOR THIRD, FOURTH, OR FIFTH ORDER POLYNOMIAL COEFFICIENTS, A LIBRARY OF KNOWN DISTANCES ALONG THE WIRE, AND A LIBRARY OF PRESET LIMITS INTO THE DATA STORAGE
713
7B

FIGURE 7B

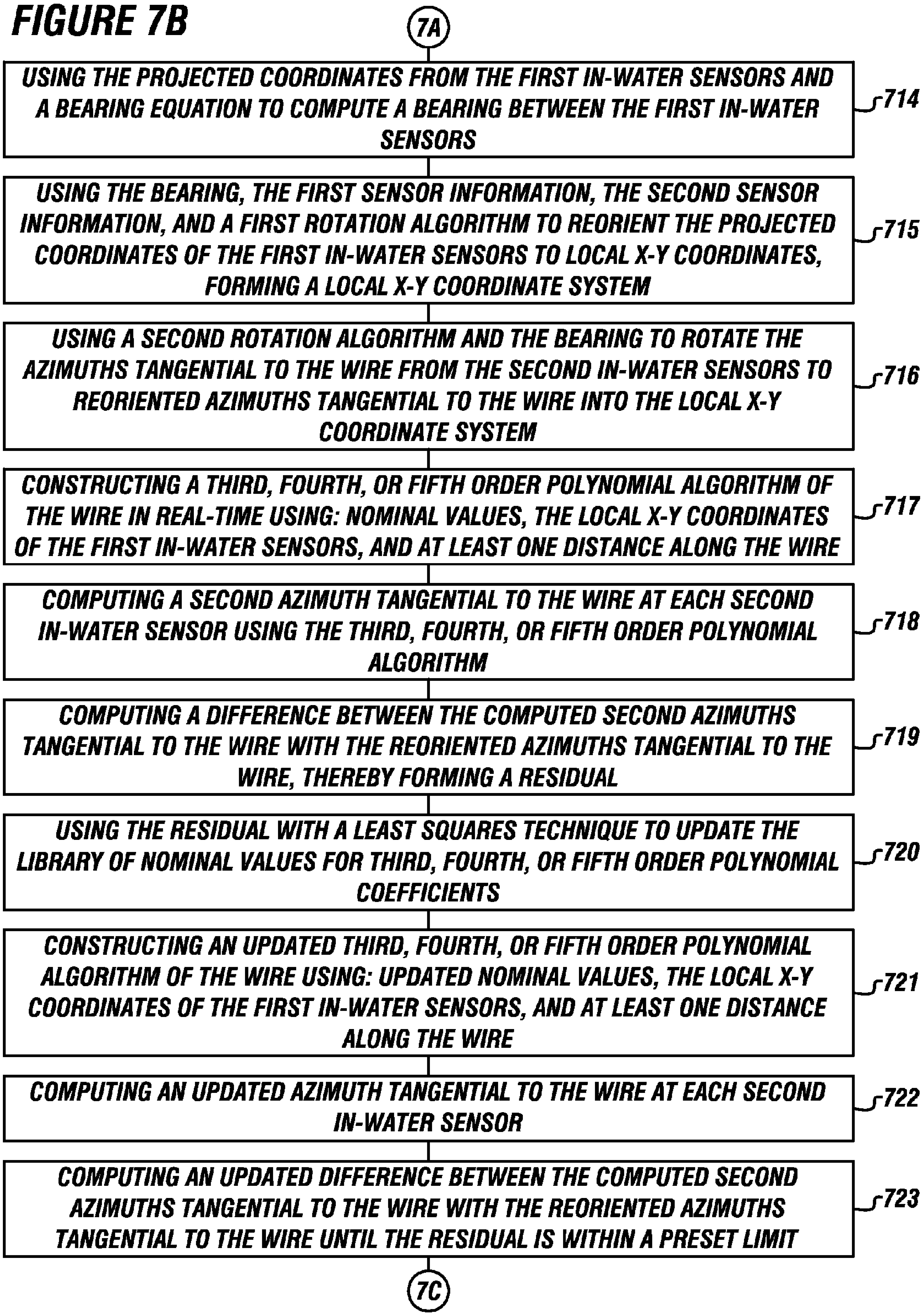
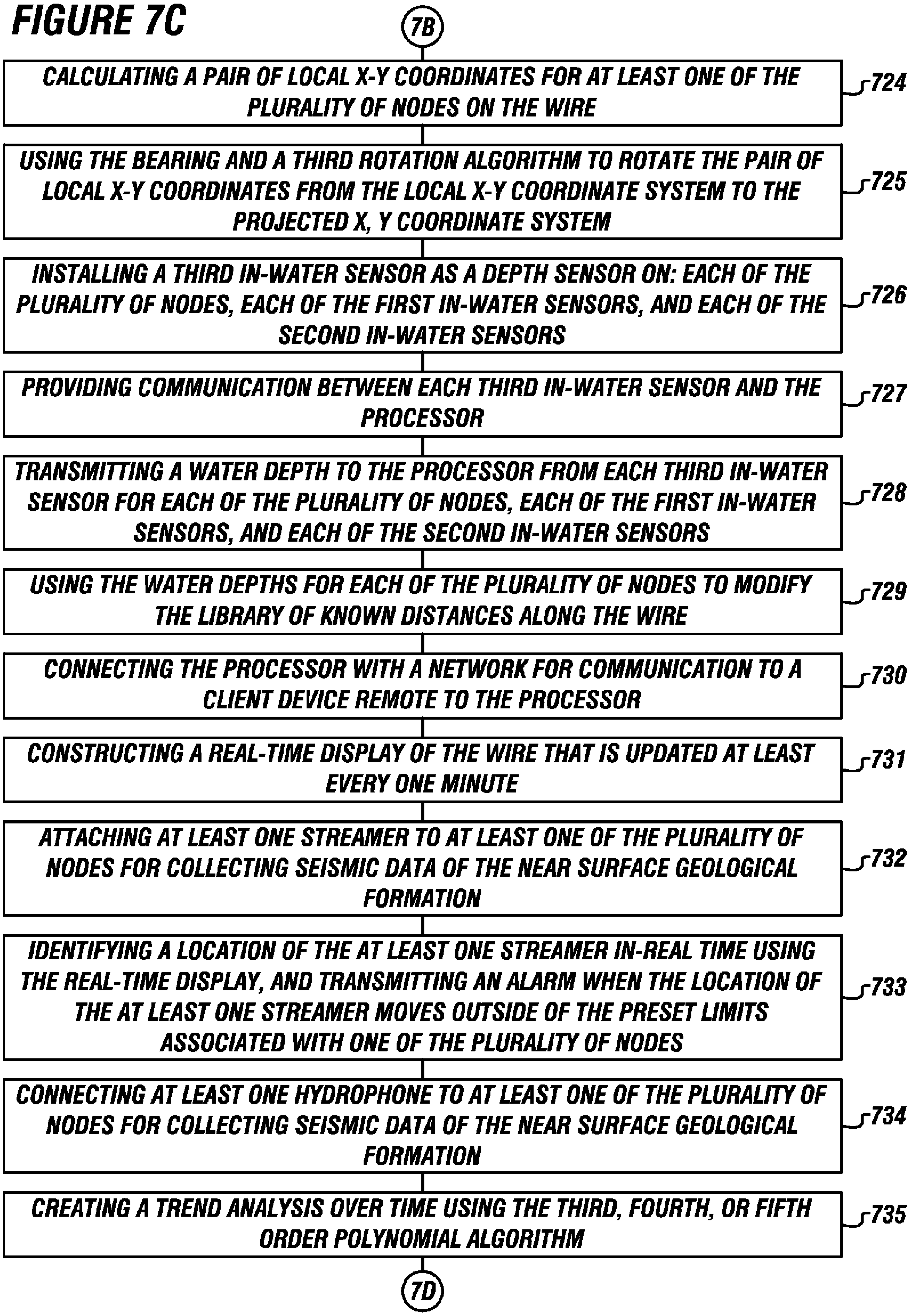

7A
USING THE PROJECTED COORDINATES FROM THE FIRST IN-WATER SENSORS AND A BEARING EQUATION TO COMPUTE A BEARING BETWEEN THE FIRST IN-WATER SENSORS
714
USING THE BEARING, THE FIRST SENSOR INFORMATION, THE SECOND SENSOR INFORMATION, AND A FIRST ROTATION ALGORITHM TO REORIENT THE PROJECTED COORDINATES OF THE FIRST IN-WATER SENSORS TO LOCAL X-Y COORDINATES, FORMING A LOCAL X-Y COORDINATE SYSTEM
715
USING A SECOND ROTATION ALGORITHM AND THE BEARING TO ROTATE THE AZIMUTHS TANGENTIAL TO THE WIRE FROM THE SECOND IN-WATER SENSORS TO REORIENTED AZIMUTHS TANGENTIAL TO THE WIRE INTO THE LOCAL X-Y COORDINATE SYSTEM
716
CONSTRUCTING A THIRD, FOURTH, OR FIFTH ORDER POLYNOMIAL ALGORITHM OF THE WIRE IN REAL-TIME USING: NOMINAL VALUES, THE LOCAL X-Y COORDINATES OF THE FIRST IN-WATER SENSORS, AND AT LEAST ONE DISTANCE ALONG THE WIRE
717
COMPUTING A SECOND AZIMUTH TANGENTIAL TO THE WIRE AT EACH SECOND IN-WATER SENSOR USING THE THIRD, FOURTH, OR FIFTH ORDER POLYNOMIAL ALGORITHM
718
COMPUTING A DIFFERENCE BETWEEN THE COMPUTED SECOND AZIMUTHS TANGENTIAL TO THE WIRE WITH THE REORIENTED AZIMUTHS TANGENTIAL TO THE WIRE, THEREBY FORMING A RESIDUAL
719
USING THE RESIDUAL WITH A LEAST SQUARES TECHNIQUE TO UPDATE THE LIBRARY OF NOMINAL VALUES FOR THIRD, FOURTH, OR FIFTH ORDER POLYNOMIAL COEFFICIENTS
720
CONSTRUCTING AN UPDATED THIRD, FOURTH, OR FIFTH ORDER POLYNOMIAL ALGORITHM OF THE WIRE USING: UPDATED NOMINAL VALUES, THE LOCAL X-Y COORDINATES OF THE FIRST IN-WATER SENSORS, AND AT LEAST ONE DISTANCE ALONG THE WIRE
721
COMPUTING AN UPDATED AZIMUTH TANGENTIAL TO THE WIRE AT EACH SECOND IN-WATER SENSOR
722
COMPUTING AN UPDATED DIFFERENCE BETWEEN THE COMPUTED SECOND AZIMUTHS TANGENTIAL TO THE WIRE WITH THE REORIENTED AZIMUTHS TANGENTIAL TO THE WIRE UNTIL THE RESIDUAL IS WITHIN A PRESET LIMIT
723
7C

FIGURE 7C


7B
CALCULATING A PAIR OF LOCAL X-Y COORDINATES FOR AT LEAST ONE OF THE PLURALITY OF NODES ON THE WIRE
724
USING THE BEARING AND A THIRD ROTATION ALGORITHM TO ROTATE THE PAIR OF LOCAL X-Y COORDINATES FROM THE LOCAL X-Y COORDINATE SYSTEM TO THE PROJECTED X, Y COORDINATE SYSTEM
725
INSTALLING A THIRD IN-WATER SENSOR AS A DEPTH SENSOR ON: EACH OF THE PLURALITY OF NODES, EACH OF THE FIRST IN-WATER SENSORS, AND EACH OF THE SECOND IN-WATER SENSORS
726
PROVIDING COMMUNICATION BETWEEN EACH THIRD IN-WATER SENSOR AND THE PROCESSOR
727
TRANSMITTING A WATER DEPTH TO THE PROCESSOR FROM EACH THIRD IN-WATER SENSOR FOR EACH OF THE PLURALITY OF NODES, EACH OF THE FIRST IN-WATER SENSORS, AND EACH OF THE SECOND IN-WATER SENSORS
728
USING THE WATER DEPTHS FOR EACH OF THE PLURALITY OF NODES TO MODIFY THE LIBRARY OF KNOWN DISTANCES ALONG THE WIRE
729
CONNECTING THE PROCESSOR WITH A NETWORK FOR COMMUNICATION TO A CLIENT DEVICE REMOTE TO THE PROCESSOR
730
CONSTRUCTING A REAL-TIME DISPLAY OF THE WIRE THAT IS UPDATED AT LEAST EVERY ONE MINUTE
731
ATTACHING AT LEAST ONE STREAMER TO AT LEAST ONE OF THE PLURALITY OF NODES FOR COLLECTING SEISMIC DATA OF THE NEAR SURFACE GEOLOGICAL FORMATION
732
IDENTIFYING A LOCATION OF THE AT LEAST ONE STREAMER IN-REAL TIME USING THE REAL-TIME DISPLAY, AND TRANSMITTING AN ALARM WHEN THE LOCATION OF THE AT LEAST ONE STREAMER MOVES OUTSIDE OF THE PRESET LIMITS ASSOCIATED WITH ONE OF THE PLURALITY OF NODES
733
CONNECTING AT LEAST ONE HYDROPHONE TO AT LEAST ONE OF THE PLURALITY OF NODES FOR COLLECTING SEISMIC DATA OF THE NEAR SURFACE GEOLOGICAL FORMATION
734
CREATING A TREND ANALYSIS OVER TIME USING THE THIRD, FOURTH, OR FIFTH ORDER POLYNOMIAL ALGORITHM
735
7D

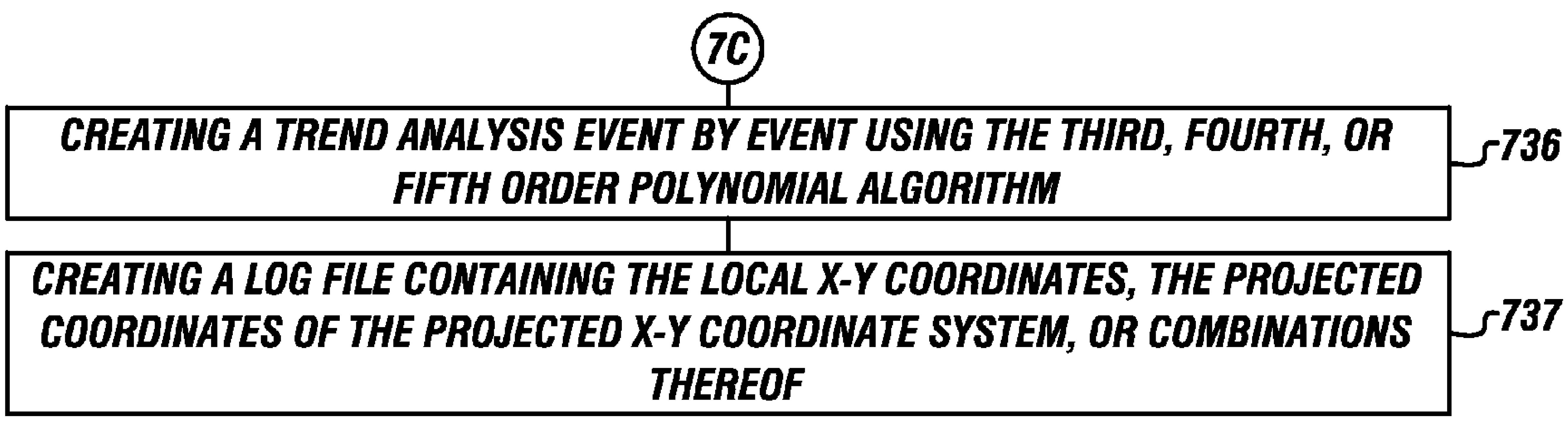

7C
CREATING A TREND ANALYSIS EVENT BY EVENT USING THE THIRD, FOURTH, OR FIFTH ORDER POLYNOMIAL ALGORITHM
736
CREATING A LOG FILE CONTAINING THE LOCAL X-Y COORDINATES, THE PROJECTED COORDINATES OF THE PROJECTED X-Y COORDINATE SYSTEM, OR COMBINATIONS THEREOF
737

FIGURE 7D

METHOD FOR POSITIONING A WIRE USING SENSOR INFORMATION

FIELD

The present embodiments generally relate to a method for determining projected coordinates in a projected coordinate system for at least one node on a wire.

BACKGROUND

A need exists for an improved seismic positioning method for positioning wires pulled from a floating vessel over a near surface geological formation.

The present embodiments meet these needs.

BRIEF DESCRIPTION OF THE DRAWINGS

The detailed description will be better understood in conjunction with the accompanying drawings as follows:

FIG. **1** depicts a wire being towed from a floating vessel.

FIGS. **2**A-**2**B depict local coordinates on a local coordinate system and projected coordinates on a projected coordinate system.

FIGS. **3**A-**3**B depict embodiments of a trend analysis over time and a trend analysis event-by-event.

FIG. **4** depicts an embodiment of a log file.

FIG. **5** depicts an embodiment of a portion of a real-time display.

FIGS. **6**A-**6**D depict an embodiment of a data storage.

FIGS. **7**A-**7**D depict an embodiment of the method.

The present embodiments are detailed below with reference to the listed Figures.

DETAILED DESCRIPTION OF THE EMBODIMENTS

Before explaining the present method in detail, it is to be understood that the method is not limited to the particular embodiments and that it can be practiced or carried out in various ways.

The present embodiments relate to a method for determining projected coordinates in a projected coordinate system for at least one node on a wire having a plurality of nodes.

The method can include securing two separated tow lines to a floating vessel, such as using cleats on the floating vessel or any suitable connector. Each tow line can have a diverter on one end.

The method can include deploying the wire between the two separated tow lines. For example, the wire can be connected at each end to the diverter of each tow line. The method can include installing at least a pair of first in-water sensors on the wire. Each first in-water sensor can be positioned proximate to an end of the wire.

Each first in-water sensor can be a sensor embedded in the wire, a sensor positioned adjacent one of the plurality of nodes on the wire, a sensor proximate to the wire, a sensor on a buoy towed from the wire, or combinations thereof.

The method can include using the pair of first in-water sensors to collect and transmit first sensor information to a processor in communication with a data storage.

The method can include using the processor and the sensor information to determine projected coordinates for a position on the wire. For example, the sensor information can be global positioning system sensor information and compass heading information that can be used to determine projected coordinates.

The method can include installing at least a pair of second in-water sensors on the wire. Each second in-water sensor can be a sensor embedded in the wire, a sensor attached to the wire, or combinations thereof.

The method can include using the second in-water sensors to collect and transmit second sensor information to the processor.

The method can include using the processor, the second sensor information, and an algorithm for computing azimuths tangential to the wire to compute a first azimuth tangential to the wire for each second in-water sensor. The algorithm for computing azimuths tangential to the wire can be a third, fourth, and/or fifth order polynomial algorithm.

The method can include loading a library of nominal values for third, fourth, and/or fifth order polynomial coefficients, a library of known distances along the wire, and a library of preset limits into the data storage.

The method can include using the projected coordinates from the first in-water sensors and a bearing equation to compute a bearing between the first in-water sensors.

The method can include using the bearing, the first sensor information, the second sensor information, and a first rotation algorithm to reorient the projected coordinates of the first in-water sensors to local x-y coordinates, thereby forming a local x-y coordinate system.

The method can include using the rotation algorithm and the bearing to rotate the azimuths tangential to the wire from the second in-water sensors to reoriented azimuths tangential to the wire of the second in-water sensors into the local x-y coordinate system.

The method can include constructing the third, fourth, and/or fifth order polynomial algorithm of the wire in real-time using nominal values from the library of nominal values for the third, fourth, and/or fifth order polynomial coefficients, the local x-y coordinates of the first in-water sensors, and at least one distance along the wire from the library of known distances along the wire.

The method can include computing a second azimuth tangential to the wire at each second in-water sensor using the third, fourth, and/or fifth order polynomial algorithm.

The method can include computing a difference between the computed second azimuths tangential to the wire with the reoriented azimuths tangential to the wire to form a residual.

The method can include using the residual with a least squares technique to update the library of nominal values for third, fourth, and/or fifth order polynomial coefficients.

The method can include constructing an updated third, fourth, and/or fifth order polynomial algorithm of the wire using updated nominal values from the library of nominal values for third, fourth, and/or fifth order polynomial coefficients, the local x-y coordinates of the first in-water sensors, and at least one distance along the wire from the library of known distances along the wire.

The method can include computing an updated azimuth tangential to the wire at each second in-water sensor using the updated third, fourth, and/or fifth order polynomial algorithm.

The method can include computing an updated difference between the computed second azimuths tangential to the wire with the reoriented azimuths tangential to the wire until the residual is within a preset limit of the library of preset limits.

The method can include calculating a pair of local x-y coordinates for at least one of the plurality of nodes on the wire.

The method can include using the bearing and the third, fourth, and/or fifth order polynomial algorithm to rotate the pair of local x-y coordinates from the local x-y coordinate system to the projected x-y coordinate system.

The computer implemented method can include installing depth sensors to identify a water depth for each of the plurality of nodes or for each in-water sensor on the wire, and transmitting water depth sensor information from the depth sensors to the processor for use in forming the projected coordinates.

The computer implemented method can include determining an absolute position for each in-water sensor, each of the plurality of nodes, or determining a specific distance on the wire using global positioning system sensors, laser sensors, acoustic sensors, or combinations thereof.

The computer implemented method can include connecting the processor with a network for communication to a client device remote to the processor, allowing for remote monitoring. The client device can be a mobile phone, a computer, a laptop, a tablet computer or a similar device.

The computer implemented method can include computing the projected coordinates in real-time as the floating vessel traverses over a near surface geological formation.

The computer implemented method can include constructing a real-time display of the wire that is updated at least every one minute. The real-time display can be constructed using the computer instructions described below.

The computer implemented method can include identifying a location of at least one streamer on at least one of the plurality of nodes in-real time using the real-time display, and transmitting an alarm when the location of the at least one streamer moves outside of the preset limits associated with one of the plurality of nodes.

In one or more embodiments, the wire can include at least one streamer connected to at least one of the plurality of nodes for collecting seismic data of near surface geological formations.

In one or more embodiments, the wire can include at least one hydrophone connected to at least one of the plurality of nodes for collecting seismic data of a near surface geological formation.

The computer implemented method can include creating a trend analysis over time using the third, fourth, and/or fifth order polynomial algorithm. The trend analysis over time can be created using the computer instructions described herein.

The computer implemented method can include creating a trend analysis event-by-event using the third, fourth, and/or fifth order polynomial algorithm. The trend analysis event-by-event can be created using the computer instructions described herein.

The computer implemented method can include creating a log file containing the local x-y coordinates, the projected coordinates of the projected x-y coordinate system, or combinations thereof.

The computer implemented method can include receiving with the sensor information a time stamp associated with a specific sensor measurement taken by the in-water sensors.

One or more embodiments relate to a system that can be used to implement one or more embodiments of the method. The system can be a computer implemented system. A processor can use computer instructions and other data stored in a data storage to perform one or more portions of the method.

The system can be used to position equipment used to detect near surface geology formations during high resolution marine geophysical surveying.

The wire can be secured to two separated tow lines that are both secured to a floating vessel. For example, each tow line can have a diverter attached thereto opposite the floating vessel, and the wire can be secured to the diverters. The wire can form a curve. The floating vessel can be a geophysical survey vessel.

The tow lines can be wire rope, electrical wire, cable, polymer rope, hemp rope, or combinations thereof. The tow lines can be attached to the floating vessel by any suitable connector, such as cleats.

The diverters can be those made by The Baro Companies, of Stafford, Tex.

The wire can be wire made by Geometrics, and can have a plurality of nodes disposed along a length of the wire.

Each node can be a determined point along the length of the wire. For example, the node can be at a tow point for a streamer, a location of an in-water sensor, a tow point for a hydrophone, or any other location along the wire.

The projected coordinates that are determined using the system can be coordinates, such as x-y coordinates on the projected coordinate system. The projected coordinate system can be a Cartesian coordinate system projected over a body of water, such as a Universal Transverse Mercator Grid in the Gulf of Mexico.

The system can be used to determine a projected coordinate for each of the plurality of nodes on the wire.

The system can include at least a pair of first in-water sensors. Each first in-water sensor can be positioned proximate to an end of the wire. An example of a first in-water sensor is a sensor available from PBX Systems, which provides GPS sensor data.

Each first in-water sensor can be embedded in the wire, positioned adjacent one of the plurality of nodes on the wire, proximate to the wire, on a buoy towed from the wire, or combinations thereof. The buoy can be a floating piece of foam or the like.

Each first in-water sensor can be deployed to determine the projected coordinates for a position on the wire.

In one or more embodiments each first in-water sensor can be a global positioning system sensor; a laser sensor, such as an MDL Fanbeam type sensor; an acoustic sensor, such as a Sonardyne type sensor; or combinations thereof.

In one or more embodiments the system can account for changes in the shape of the wire to provide accurate node locations using the global positioning system sensor, compass headings, and other information. For example, the compass headings can be detected by a 3004 digital compass made by Spartan Electronics.

The system can include at least a pair of second in-water sensors. Each second in-water sensor can be embedded in the wire, attached to the wire, or combinations thereof.

The second in-water sensors can be deployed to provide azimuths tangential to the wire.

The term "azimuths tangential to the wire" refers to the bearing of the wire at the node where the second in-water sensor for determining compass headings is attached.

The system can include a processor in communication with a data storage, each first in-water sensor, and each second in-water sensor.

The processor can be configured to process in real-time as the floating vessel traverses over a near surface geological formation.

Real-time processing can include collecting and processing data from about every 1 second to about every 20 seconds.

A near surface geological formation can be an oil reservoir, a gas reservoir, a salt dome, or other geological formations.

In one or more embodiments, instead of or in addition to processing in real-time, the processor can perform processing after the floating vessel has acquired information from all of the first in-water sensors and all of the second in-water sensors. For example, the processing can be performed immediately after all of the sensor information is collected or any time thereafter.

The data storage can be a hard drive, a jump drive, or any computer readable medium. One or more embodiments of the data storage can include a dynamic information database, such as a structured query language (SQL) server database, for storing data within, such as the sensor information.

A library of nominal values for third, fourth, and/or fifth order polynomial coefficients can be stored in the data storage.

The library of nominal values for third, fourth, and/or fifth order polynomial coefficients can include nominal values. The nominal values can be any number.

A library of known distances along the wire can be stored in the data storage. The library of known distances along the wire can include distances from the connection of the wire to the first tow line to each of the first in-water sensors.

The library of known distances along the wire can include distances from each first in-water sensor to each second in-water sensor.

The library of known distances along the wire can include distances from each node to each other node, or from each in-water sensor to each node.

The library of known distances along the wire can include any other known distance along or relative to the wire.

A library of preset limits can be stored in the data storage comprising preset limits. For example, the preset limits can include a measurement between two nodes, a water depth, a compass heading, a rate of change in compass heading, or other measurements.

The data storage can have computer instructions for instructing the processor to receive sensor information from each first in-water sensor and each second in-water sensor. For example, each first in-water sensor and each second in-water sensor can collect sensor information and can transmit that sensor information to the processor for storage on the data storage.

The sensor information can include an azimuth tangential to the wire, the projected coordinates for a position on the wire, a water depth of a node, a compass heading of a node, a global positioning system location of a node, or combinations thereof.

Each portion of sensor information can include a time stamp associated with a specific sensor measurement. The time stamps can identify the time that the sensor measurement was taken and validated.

The data storage can have computer instructions to instruct the processor to use the projected coordinates from the first in-water sensors to compute a bearing between the first in-water sensors.

For example, the bearing can be computed by the following equation: $\theta=\arctan((y1-y2)/(x1-x2))$, with x1 and y1 being the projected coordinates of one first in-water sensor, and x2 and t2 being the projected coordinates of another first in-water sensor.

The data storage can have computer instructions to instruct the processor to use the bearing with the sensor information and a first rotation algorithm to reorient the projected coordinates of all of the first in-water sensors to local x-y coordinates, forming a local x-y coordinate system.

In one or more embodiments the first rotation algorithm can be used to rotate the projected coordinates to the local coordinates by a rotation angle θ. For example, the x coordinate of the projected coordinates can be rotated by the following equation: $x=E^*\cos\theta+N^*\sin\theta$. The y coordinate of the projected coordinates can be rotated by the following equation: $y=-E^*\sin\theta+N^*\cos\theta$. In the first rotation algorithm equations above, x is the local x coordinate, y is the local y coordinate, E is the projected easting coordinate, N is the projected northing coordinate, and θ is the rotation angle.

The data storage can have computer instructions to instruct the processor to rotate the azimuth tangential to the wire from the second in-water sensors using the bearing and a second rotation algorithm to reorient all azimuths tangential to the wire of all the second in-water sensors into the local x-y coordinate system.

In one or more embodiments the second rotation algorithm can be used to rotate the azimuth tangential to the wire into the local x-y coordinate system by a rotation angle θ. For example, a rotated azimuth tangential to the wire can be determined by: $A'=A+\theta$. In the second rotation algorithm A' is the rotated azimuth, A is the measured azimuth, and θ is the rotation angle.

The data storage can have computer instructions to instruct the processor to construct a third, fourth, and/or fifth order polynomial algorithm of the wire in real-time.

For example, a third order polynomial algorithm of the wire can be: $y=ax^3+bx^2+cx+d$. A fourth order polynomial algorithm of the wire can be: $y=ax^4+bx^3+cx^2+dx+e$. A fifth order polynomial algorithm of the wire can be: $y=ax^5+bx^4+cx^3+dx^2+ex+f$.

Within the third, fourth, and/or fifth order polynomial algorithm, x and y can both be coordinates along the wire, and a, b, c, d, e, and f can each be coefficients to be solved by a least squares technique.

For example, survey observations obtained can be the y coordinate at the head of the wire derived from the global positioning system sensors and tangential azimuths along the wire derived from compass headings of the wire.

The third, fourth, and/or fifth order polynomial algorithm can provide accurate modeling within about a decimeter in extreme cross currents.

In benign conditions, the third, fourth, and/or fifth order polynomial algorithm can provide even more accurate modeling.

The third, fourth, and/or fifth order polynomial algorithm of the wire can be constructed using the nominal values from the library of nominal values for third, fourth, and/or fifth order polynomial coefficients, the local x-y coordinates of the first in-water sensors, and at least one distance along the wire from the library of known distances along the wire.

The data storage can have computer instructions to instruct the processor to compute an azimuth tangential to the wire at each second in-water sensor using the third, fourth, and/or fifth order polynomial algorithm.

As an example of computing an azimuth tangential using the third order polynomial algorithm, the equation, $y=ax^3+bx^2+cx+d$, can be used as a third order polynomial definition of a curve.

The equation, $y=ax^3+bx^2+cx+d$, can be differentiated by x, with a solution of: $dy/dx=3ax^2+2bx+c$, as the slope of the tangent at x.

The slope of the tangent at x can be converted to an azimuth using the following equation: $3\pi/2-\arctan(dy/dx)$.

The data storage can have computer instructions to instruct the processor to compute a difference between the computed azimuths tangential to the wire with the reoriented azimuths tangential to the wire from all of the second in-water sensors, thereby forming a residual.

For example, the difference between the computed azimuth tangential and the reoriented azimuths tangential can be computed by subtracting one from the other.

The data storage can have computer instructions to instruct the processor to use the residual with a linear least squares technique to update the library of nominal values for third, fourth, and/or fifth order polynomial coefficients.

In the linear least squares technique, the overall solution can minimize the sum of the squares of the residuals computed in solving every single equation using the third, fourth, and/or fifth order polynomial.

A regression model is a linear one when the model comprises a linear combination of the parameters. The generalization of the n-dimensional Pythagorean theorem to infinite-dimensional real inner product spaces is known as Parseval's identity or Parseval's equation. Particular examples of such a representation of a function are the Fourier series and the generalized Fourier series.

The data storage can have computer instructions to instruct the processor to construct an updated third, fourth, and/or fifth order polynomial algorithm of the wire using updated nominal values from the updated library of nominal values for third, fourth, and/or fifth order polynomial coefficients, the local x-y coordinates of the first in-water sensors, and at least one distance along the wire from the library of known distances along the wire.

The data storage can have computer instructions to instruct the processor to compute an updated azimuth tangential to the wire at each second in-water sensor.

The data storage can have computer instructions to instruct the processor to compute an updated difference between the computed updated azimuths tangential to the wire with the reoriented azimuths tangential to the wire from all of the second in-water sensors until the residual is determined to be within one of the preset limits from the library of preset limits.

The data storage can have computer instructions to instruct the processor to calculate a pair of local x-y coordinates for at least one of the plurality of nodes on the wire. For example, each pair of local x-y coordinates can be calculated using the third, fourth, and/or fifth order polynomial algorithms.

The data storage can have computer instructions to instruct the processor to use the bearing and a third rotation algorithm to rotate the pair of local x-y coordinates for at least one of the plurality of nodes on the wire from the local x-y coordinate system to the projected coordinate system.

In one or more embodiments the third rotation algorithm can be used to rotate from the local coordinates to the projected coordinates by a rotation angle θ. For example, third rotation algorithm can include: $E=x*\cos(\theta)-y*\sin(\theta)$, and $N=x*\sin(\theta)+y*\cos(\theta)$. Within the third rotation algorithm x is the local x coordinate, y is the local y coordinate, E is the projected easting coordinate, N is the projected northing coordinate, and θ is the rotation angle which is the computed bearing.

One or more embodiments of the system can include a third in-water sensor on each of the plurality of nodes, each of the first in-water sensors, and each of the second in-water sensors. Each third in-water sensor can be in communication with the processor. The third in-water sensors can be depth sensors that can measure water depths for each of the plurality of nodes, each of the first in-water sensors, and each of the second in-water sensors, and can transmit the measured water depths to the processor.

In one or more embodiments, a network can be in communication with the processor. The network can be satellite network, a cellular network, the internet, or Ethernet cables connected between processor and the in-water sensors, the nodes, or both.

The data storage can include computer instructions to instruct the processor to construct a real-time display of the wire. The real-time display can be a graphical user interface.

In one or more embodiments, the wire can have at least one streamer. Each streamer can be connected to at least one of the plurality of nodes. Each streamer can be configured to collect seismic data, such as a size, depth, or location of a near surface geological formation. The method and system can allow for accurate positioning of the at least one streamer.

The computer implemented method can include computer instructions in the data storage to instruct the processor to identify a location of the at least one streamer in real-time using the real-time display.

The computer implemented method can include computer instructions in the data storage to instruct the processor to transmit an alarm when the location of the at least one streamer moves outside of one of the preset limits in the library of preset limits associated with one of the plurality of nodes.

The alarm can be a text message, an email, an audible alarm, or a flashing light, and can be transmitted to a client device, another computer on the network, or presented in the real-time display. The alarm can be provided both onboard the floating vessel and remote to the floating vessel. The client device can be a mobile phone, a computer, a laptop, a tablet computer or another similar device.

For example, the library of preset limits can include preset limits associated with each of the plurality of nodes. When the location a streamer moves outside of a preset limit for the node that streamer is attached to, the alarm can be transmitted.

Each streamer can be or include a hydrophone. Each hydrophone can be connected to at least one of the plurality of nodes for collecting seismic data of a near surface geological formation.

The computer implemented method can include computer instructions in the data storage to instruct the processor to create a trend analysis over time using the third, fourth, and/or fifth order polynomial algorithm.

The computer implemented method can include computer instructions in the data storage to instruct the processor to create a trend analysis event-by-event using the third, fourth, and/or fifth order polynomial algorithm.

The computer implemented method can include computer instructions in the data storage to instruct the processor to create a log file.

The log file can contain the local x-y coordinates, the projected coordinates of the projected coordinate system, or combinations thereof.

Turning now to the Figures, FIG. **1** depicts an embodiment of a computer system for positioning a wire **16**. The wire **16** can be connected to, and stretched between, two separated tow lines, including a first tow line **18***a* and a second tow line **18***b*.

The tow lines **18***a* and **18***b* can be secured to a floating vessel **22**. Two diverters can be secured to the two tow lines **18***a* and **18***b*, including a first diverter **20***a* and a second diverter **20***b*.

The tow lines **18***a* and **18***b* can each have a length ranging from about 50 feet to about 500 feet and a diameter ranging from about ¼ of an inch to about 2 inches.

The tow lines **18***a* and **18***b* can extend from the floating vessel **22** at an angle from a centerline of the floating vessel **22**, which can range from about 90 degrees to about 180 degrees.

The wire **16** can have a plurality of nodes, such as a first node **14***a*, a second node **14***b*, a third node **14***c*, a fourth node

14*d*, a fifth node 14*e*, and a sixth node 14*f*. The wire 16 can have from about 2 nodes to about 100 nodes.

The wire 16 can have a length ranging from about 50 feet to about 500 feet and a diameter ranging from about ¼ of an inch to about 2 inches.

One or more streamers can be attached to one or more of the plurality of nodes 14*a*-14*f*. For example a first streamer 116*a* can be attached to the first node 14*a* and a second streamer 116*b* can be attached to the second node 14*b*.

The streamers 116*a* and 116*b* can have a length ranging from about 1 foot to about 500 feet. The streamers 116*a* and 116*b* can collect seismic data of a near surface geological formation 110, such as a fault.

One or more hydrophones can be attached to one or more of the plurality of nodes 14*a*-14*f*. For example, a first hydrophone 120*a* can be attached to the third node 14*c* and a second hydrophone 120*b* can be attached to the fourth node 14*d*.

The hydrophones 120*a* and 120*b* can be those made by Teledyne Instruments, such as a T-2BX hydrophone with an encapsulated hydrophone sensor element or the like.

The hydrophones 120*a* and 120*b* can collect seismic data of the near surface geological formation 110, such as a depth of the fault, size of the fault, or the like.

The computer system can include one or more first in-water sensors 24*a*, 24*b*, 24*c*, and 24*d* deployed on or proximate the wire 16.

For example, the first in-water sensor 24*a* can be deployed near the first tow line 18*a*, and can be embedded in the wire 16. The first in-water sensor 24*b* can be positioned proximate to the second tow line 18*b*. The first in-water sensor 24*c* can be towed near the wire 16. The first in-water sensor 24*d* can be supported by a buoy 26 towed from the wire 16 and can be positioned proximate to the wire 16.

The computer system can include one or more second in-water sensors 28*a* and 28*b* deployed on the wire 16. The second in-water sensors 28*a* and 28*b* can be deployed to provide azimuths tangential to the wire 16.

The second in-water sensor 28*a* can be embedded in the wire 16 at the first node 14*a*, and the second in-water sensor 28*b* can be attached to the wire 16 between the second node 14*b* and the third node 14*c*.

The computer system can include a processor 32 in communication with a data storage 34, which can be disposed on the floating vessel 22.

The processor 32 can be in communication with the first in-water sensors 24*a*-24*d* and the second in-water sensors 28*a* and 28*b*, such as through cables 57*a* and 57*b*, which can be Ethernet cables.

The system can also include third in-water sensors, such as third in-water sensors 29*a*, 29*b*, and 29*c*, which can be in communication with the processor 32 through the cables 57*a* and 57*b*.

The third in-water sensor 29*a* is shown on the fifth node 14*e*, the third in-water sensor 29*b* is shown on the second in-water sensor 28*b*, and the third in-water sensor 29*c* is shown on the first in-water sensor 24*c*. The system can include any number of first in-water sensors, second in-water sensors, and third in-water sensors disposed at various positions along the wire 16.

The third in-water sensors 29*a*, 29*b* and 29*c* can be depth sensors that transmit water depths for each of the plurality of nodes 14*a*-14*f*, each of the first in-water sensors 24*a*-24*d*, and each of the second in-water sensors 28*a* and 28*b*.

A client device 13 can be in communication with the processor 32, such as through a network 108, for remote monitoring. For example, the client device 13 can receive one or more alarms 128. The alarms 128 can be flashing lights, an audible signal, or the like.

In operation, the floating vessel 22 can move along a surface of the water pulling the tow lines 18*a* and 18*b*, the wire 16, the streamers 116*a* and 116*b*, and the hydrophones 120*a* and 120*b*.

The first in-water sensors 24*a*-24*d*, the second in-water sensors 28*a* and 28*b*, and the third in-water sensors 29*a*, 29*b* and 29*c* can be disposed above or below the surface of the water, and can collect sensor information for transmission to the processor 32 via the cables 57*a* and 57*b*.

The processor 32 can receive the sensor information, store the sensor information in the data storage 34, and utilize various computer instructions in the data storage 34 to perform calculations on the sensor information for positioning the plurality of nodes 14*a*-14*f* of the wire 16.

The processor 32 can utilize computer instructions and data stored in the data storage 34 to perform various calculations, as described herein, to determine a position of the wire 16, a direction of the wire 16, and a velocity of the wire 16.

FIG. 2A depicts an embodiment of a local x-y coordinate system 64 with a position of the wire 16 plotted thereon.

The local x-y coordinate system 64 can be presented, such as on a display device or monitor in communication with the processor, as a portion of the real-time display.

The y-axis and x-axis both represent spatial measurements, such as in meters, of positions within the local x-y coordinate system 64.

On the plot of the wire 16, the position of the first in-water sensors 24*a* and 24*b* and the position of the second in-water sensor 28*c* are shown. For example, the local x-y coordinates 62*a* and 62*b* associated with the second in-water sensor 28*c* are shown plotted in the local x-y coordinate system 64.

A computed bearing 58 between the first in-water sensor 24*a* and the first in-water sensor 24*b* can be depicted on the local x-y coordinate system 64.

An azimuth 30 tangential to the wire 16 can also be depicted on the local x-y coordinate system 64.

FIG. 2B depicts an embodiment of a projected coordinate system 12 with a position of the wire 16 plotted thereon.

The projected coordinate system 12 can be presented, such as on the display device or monitor in communication with the processor, as a portion of the real-time display.

In the depicted projected coordinate system 12, the y-axis represents spatial measurements in a northing coordinate of the projected coordinate system 12, and the x-axis represents spatial measurements in an easting coordinate of the projected coordinate system 12.

The origin of the projected coordinate system 12 can be determined using the projected coordinates from at least one of the first in-water sensors 24*a* and 24*b*. For example, the first in-water sensor 24*a* can have projected coordinates 10*a* and 10*b* associated therewith and plotted within the projected coordinate system 12.

The computed bearing 58 between the first in-water sensor 24*a* and the first in-water sensor 24*b* can be depicted within the projected coordinate system 12.

The azimuth 30 tangential to the wire 16 from the second in-water sensor 28*c* can also be depicted within the projected coordinate system 12.

A representation of the local x-y coordinate system 64 can be depicted within the projected coordinate system 12 to show the relationship between the local x-y coordinate system 64 and the projected coordinate system 12.

FIG. **3**A depicts an embodiment of the trend analysis over time **132** and FIG. **3**B depicts an embodiment of a trend analysis event-by-event **136**.

For example, a distance between two nodes of the plurality of nodes on the wire can be plotted with respect to time, such as in seconds, to form the trend analysis over time **132**.

A distance between two nodes of the plurality of nodes on the wire can be plotted with respect to events to form the trend analysis event-by-event **136**. For example, an event can be the release of seismic energy. The events can be sequential.

FIG. **4** depicts an embodiment of the log file **140**. The log file **140** can be created by tabulating various portions of data and sensor information within the data storage.

For example, the log file **140** can include a first column **143***a* showing various nodes of the plurality of nodes, such as the first node **14***a* in a first row of the log file **140**, the second node **14***b* in a second row of the log file **140**, and the third node **14***c* in a third row of the log file **140**.

The log file **140** can include a second column **143***b* showing the local x-coordinate of the local x-y coordinates that are associated with the node in that particular row of the log file **140**. For example, the local x-coordinate **62***a* can be 3 for the first node **14***a*, the local x-coordinate **62***c* can be 4 for the second node **14***b*, and the local x-coordinate **62***e* can be 5 for the third node **14***c*.

The log file **140** can include a third column **143***c* showing the local y-coordinate of the local x-y coordinates that are associated with the node in that particular row of the log file **140**. For example, the local y-coordinate **62***b* can be 7 for the first node **14***a*, the local y-coordinate **62***d* can be 8 for the second node **14***b*, and the local y-coordinate **62***f* can be 9 for the third node **14***c*.

The log file **140** can include a fourth column **143***d* showing the projected x-coordinate of the projected coordinates that are associated with the node in that particular row of the log file **140**. For example, the projected x-coordinate **10***a* can be 10000 for the first node **14***a*, the projected x-coordinate **10***c* can be 10001 for the second node **14***b*, and the projected x-coordinate **10***e* can be 10002 for the third node **14***c*.

The log file **140** can include a fifth column **143***e* showing the projected y-coordinate of the projected coordinates that are associated with the node in that particular row of the log file **140**. For example, the projected y-coordinate **10***b* can be 11001 for the first node **14***a*, the projected y-coordinate **10***d* can be 11002 for the second node **14***b*, and the projected y-coordinate **10***f* can be 11003 for the third node **14***c*.

The log file **140** can include a sixth column **143***f* showing events associated with the nodes in the first column **143***a*. For example, a first event **119***a* can be associated with the first node **14***a*, a second event **119***b* can be associated with the second node **14***b*, and a third event **119***c* can be associated with the third node **14***c*.

The log file **140** can include a seventh column **143***g* showing a time stamp associated with each event. For example, a time stamp **142***a*, which can be 1:01 pm for example, can be associated with the first event **119***a*. A time stamp **142***b*, which can be 1:02 pm for example, can be associated with the second event **119***b*. A time stamp **142***c*, which can be 1:03 pm for example, can be associated with third event **119***c*.

FIG. **5** depicts an embodiment of a portion of the real-time display **114**.

The real-time display **114** can present a plot **115** of the wire **16**. The real-time display **114** can present a depth profile **117** for the wire **16** and the streamers **116**.

The depth profile **117** can be a plot of the water depths **31***b* of the wire **16** and the streamers **116** with respect to events **119**.

The real-time display **114** can present a depiction of node separations **121** showing the distance between nodes along the wire **16**.

The real-time display **114** can present compass data **123**, such as compass headings of the second in-water sensors.

The real-time display **114** can present water depth data, such as water depths **31***a* of the first in-water sensors, the second in-water sensors, the streamers **116**, the plurality of nodes, and/or the wire **16**.

The real-time display **114** can present network solution data **125**, such as polynomial coefficients. For example, the polynomial coefficient Ax, which is equal to 0.01, is shown along with other polynomial coefficients.

The real-time display **114** can present event information **127**, such as an event number, here shown as 00002131, a date, and a time.

FIGS. **6**A-**6**D depict an embodiment of the data storage **34**.

The data storage **34** can include the library of nominal values for third, fourth, or fifth order polynomial coefficients **36** with nominal values **37** stored therein.

The data storage **34** can include the library of known distances along the wire **38** having at least one distance **39** along the wire, distances to each first in-water sensor **40**, distances to each second in-water sensor **42**, distances to each node of the plurality of nodes **44**, and distances to desired locations along the wire **46**.

The data storage **34** can include the library of preset limits **48** with preset limits **50**.

The data storage **34** can include computer instructions for instructing the processor to receive sensor information from each first in-water sensor and each second in-water sensor **52**.

The sensor information **54** can be stored in the data storage **34** with a time stamp **142**, and can include an azimuth **30***a* tangential to the wire, and the projected coordinates **10** for a position on the wire.

The data storage **34** can include computer instructions to instruct the processor to use the projected coordinates from the first in-water sensors to compute a bearing between the first in-water sensors, and then to use the bearing with the sensor information and a first rotation algorithm to reorient the projected coordinates of all of the first in-water sensors to local x-y coordinates, forming a local x-y coordinate system **56**.

The bearing **58** can be stored in the data storage **34**.

Also the first rotation algorithm **60***a*, a second rotation algorithm **60***b*, and a third rotation algorithm **60***c* can be stored in the data storage **34**.

The data storage **34** can include the local x-y coordinates **62** in the local x-y coordinate system **64** stored therein.

The data storage **34** can include computer instructions to instruct the processor to rotate the azimuth tangential to the wire from each second in-water sensor using the bearing and the second rotation algorithm to reorient all azimuths tangential to the wire into the local x-y coordinate system **66**.

The data storage **34** can include computer instructions to instruct the processor to construct a third, fourth, or fifth order polynomial algorithm of the wire in real-time using nominal values from the library of nominal values for third, fourth, or fifth order polynomial coefficients, the local x-y coordinates of the first in-water sensors, and at least one distance along the wire from the library of known distances along the wire **70**.

The third, fourth, or fifth order polynomial algorithm **72** can be stored in the data storage **34**.

The data storage **34** can include computer instructions to instruct the processor to compute an azimuth tangential to the wire at each second in-water sensor using the third, fourth, or fifth order polynomial algorithm **74**.

The computed azimuth **30***b* can be stored in the data storage **34**.

The data storage **34** can include computer instructions to instruct the processor to compute a difference between the computed azimuth tangential to the wire with the reoriented azimuths tangential to the wire to form a residual **76**.

The residual **78** can be stored in the data storage **34**.

The data storage **34** can include computer instructions to instruct the processor to use the residual with a least squares technique to update the library of nominal values for third, fourth, or fifth order polynomial coefficients **80**.

The linear least squares technique **82** can be stored in the data storage **34**.

The data storage **34** can include computer instructions to instruct the processor to construct an updated third, fourth, or fifth order polynomial algorithm of the wire using updated nominal values from the updated library of nominal values for third, fourth, or fifth order polynomial coefficients, the local x-y coordinates of the first in-water sensors, and at least one distance along the wire from the library of known distances along the wire **84**.

The updated third, fourth, or fifth order polynomial algorithm **86** can be stored in the data storage **34**.

The data storage **34** can include computer instructions to instruct the processor to compute an updated azimuth tangential to the wire at each second in-water sensor **88**.

The updated azimuth **30***c* can be stored in the data storage **34**.

The data storage **34** can include computer instructions to instruct the processor to compute an updated difference between the computed updated azimuth tangential to the wire and the reoriented azimuth tangential to the wire until the residual is within one of the preset limits from the library of preset limits **90**.

The data storage **34** can include computer instructions to instruct the processor to calculate a pair of local x-y coordinates for at least one of the plurality of nodes on the wire **92**.

The calculated pair of local x-y coordinates **63***a* and **63***b* can be stored in the data storage **34**.

The data storage **34** can include computer instructions to instruct the processor to use the bearing and the third rotation algorithm to rotate the pair of local x-y coordinates for at least one of the plurality of nodes on the wire from the local x-y coordinate system to the projected coordinate system **93**.

The data storage **34** can have computer instructions to instruct the processor to construct a real-time display of the wire **112**.

The data storage **34** can have computer instructions to instruct the processor to identify a location of the at least one streamer in real-time using the real-time display **122**.

The location of the at least one streamer **124** can be stored in the data storage **34**.

The data storage **34** can have computer instructions to instruct the processor to transmit an alarm when the location of the at least one streamer moves outside of one of the preset limits in the library of preset associated with one of the plurality of nodes **126**.

The data storage **34** can have computer instructions to instruct the processor to create a trend analysis over time using the third, fourth, or fifth order polynomial algorithm **130**.

The data storage **34** can have computer instructions to instruct the processor to create a trend analysis event-by-event using the third, fourth, or fifth order polynomial algorithm **134**.

The data storage **34** can have computer instructions to instruct the processor to create a log file containing the local x-y coordinates, the projected coordinates of the projected coordinate system, or combinations thereof **138**.

The data storage **34** can have computer instructions to instruct the processor to process in real-time as the floating vessel traverses over a near surface geological formation **144**, and computer instructions to instruct the processor to process after the floating vessel has acquired information from all of the first in-water sensors and all of the second in-water sensors **146**.

The data storage **34** can have computer instructions to identify a location of the at least one hydrophone in real-time using the real-time display **148**, and computer instructions to transmit an alarm when the location of the at least one hydrophone moves outside of one of the preset limits in the library of preset limits associated with one of the plurality of nodes **150**.

The data storage **34** can have computer instructions to form a library of nominal values for third, fourth, or fifth order polynomial coefficients **152**, computer instructions to form a library of known distances along the wire **154**, and computer instructions to form a library of preset limits comprising preset limits **156**.

The data storage **34** can have computer instructions to use the water depth for each of the plurality of nodes to modify the library of known distances **160**.

FIGS. **7A-7D** depict an embodiment of a computer implemented method for determining projected coordinates in a projected coordinate system for at least one node on a wire having a plurality of nodes.

The method can include securing two separated tow lines to a floating vessel, as illustrated by box **700**.

The method can include deploying the wire between the two separated tow lines, as illustrated by box **702**.

The method can include installing at least a pair of first in-water sensors on the wire and positioning each first in-water sensor proximate to an end of the wire, as illustrated by box **703**.

The method can include embedding one or more first in-water sensors in the wire, positioning one or more first in-water sensors adjacent one of the plurality of nodes, positioning one or more first in-water sensors proximate to the wire, positioning one or more first in-water sensors on a buoy towed from the wire, or combinations thereof, as illustrated by box **704**.

The method can include determining an absolute position for each in-water sensor and each of the plurality of nodes, or determining a specific distance on the wire using global positioning system sensors, laser sensors, acoustic sensors, or combinations thereof as the first in-water sensors, as illustrated by box **705**.

The method can include using the pair of first in-water sensors to collect and transmit first sensor information to a processor in communication with a data storage, as illustrated by box **706**.

The method can include using the processor and the first sensor information to determine projected coordinates for a position on the wire, as illustrated by box **707**.

The method can include computing the projected coordinates in real-time as the floating vessel traverses over a near surface geological formation, as illustrated by box **708**.

The method can include installing at least a pair of second in-water sensors on the wire by embedding the second in-water sensors in the wire, attaching the second in-water sensors to the wire, or combinations thereof, as illustrated by box **709**.

The method can include using the second in-water sensors to collect and transmit second sensor information to the processor, as illustrated by box **710**.

The method can include receiving a time stamp with the sensor information, as illustrated by box **711**.

The method can include using the processor, the second sensor information, and an algorithm for computing azimuth tangents to compute a first azimuth tangential to the wire for each second in-water sensor, as illustrated by box **712**.

The method can include loading a library of nominal values for third, fourth, or fifth order polynomial coefficients, a library of known distances along the wire, and a library of preset limits into the data storage, as illustrated by box **713**.

The method can include using the projected coordinates from the first in-water sensors and a bearing equation to compute a bearing between the first in-water sensors, as illustrated by box **714**.

The method can include using the bearing, the first sensor information, the second sensor information, and a first rotation algorithm to reorient the projected coordinates of the first in-water sensors to local x-y coordinates, forming a local x-y coordinate system, as illustrated by box **715**.

The method can include using a second rotation algorithm and the bearing to rotate the azimuths tangential to the wire from the second in-water sensors to reoriented azimuths tangential to the wire into the local x-y coordinate system, as illustrated by box **716**.

The method can include constructing a third, fourth, or fifth order polynomial algorithm of the wire in real-time using nominal values, the local x-y coordinates of the first in-water sensors, and at least one distance along the wire, as illustrated by box **717**.

The method can include computing a second azimuth tangential to the wire at each second in-water sensor using the third, fourth, or fifth order polynomial algorithm, as illustrated by box **718**.

The method can include computing a difference between the computed second azimuths tangential to the wire with the reoriented azimuths tangential to the wire, thereby forming a residual, as illustrated by box **719**.

The method can include using the residual with a least squares technique to update the library of nominal values for third, fourth, or fifth order polynomial coefficients, as illustrated by box **720**.

The method can include constructing an updated third, fourth, or fifth order polynomial algorithm of the wire using updated nominal values, the local x-y coordinates of the first in-water sensors, and at least one distance along the wire, as illustrated by box **721**.

The method can include computing an updated azimuth tangential to the wire at each second in-water sensor, as illustrated by box **722**.

The method can include computing an updated difference between the computed second azimuths tangential to the wire with the reoriented azimuths tangential to the wire until the residual is within a preset limit, as illustrated by box **723**.

The method can include calculating a pair of local x-y coordinates for at least one of the plurality of nodes on the wire, as illustrated by box **724**.

The method can include using the bearing and a third rotation algorithm to rotate the pair of local x-y coordinates from the local x-y coordinate system to the projected x, y coordinate system, as illustrated by box **725**.

The method can include installing a third in-water sensor as a depth sensor on each of the plurality of nodes, each of the first in-water sensors, and each of the second in-water sensors, as illustrated by box **726**.

The method can include providing communication between each third in-water sensor and the processor, as illustrated by box **727**.

The method can include transmitting a water depth to the processor from each third in-water sensor for each of the plurality of nodes, each of the first in-water sensors, and each of the second in-water sensors, as illustrated by box **728**.

The method can include using the water depths for each of the plurality of nodes to modify the library of known distances along the wire, as illustrated by box **729**.

The method can include connecting the processor with a network for communication to a client device remote to the processor, as illustrated by box **730**.

The method can include constructing a real-time display of the wire that is updated at least every one minute, as illustrated by box **731**.

The method can include attaching at least one streamer to at least one of the plurality of nodes for collecting seismic data of the near surface geological formation, as illustrated by box **732**.

The method can include identifying a location of the at least one streamer in-real time using the real-time display, and transmitting an alarm when the location of the at least one streamer moves outside of the preset limits associated with one of the plurality of nodes, as illustrated by box **733**.

The method can include connecting at least one hydrophone to at least one of the plurality of nodes for collecting seismic data of the near surface geological formation, as illustrated by box **734**.

The method can include creating a trend analysis over time using the third, fourth, or fifth order polynomial algorithm, as illustrated by box **735**.

The method can include creating a trend analysis event-by-event using the third, fourth, or fifth order polynomial algorithm, as illustrated by box **736**.

The method can include creating a log file containing the local x-y coordinates, the projected coordinates of the projected x-y coordinate system, or combinations thereof, as illustrated by box **737**.

While these embodiments have been described with emphasis on the embodiments, it should be understood that within the scope of the appended claims, the embodiments might be practiced other than as specifically described herein.

What is claimed is:

1. A computer implemented method for determining projected coordinates in a projected coordinate system for at least one node on a wire having a plurality of nodes, the computer implemented method comprising:

a. securing two separated tow lines to a floating vessel, wherein each tow line has a diverter;
b. deploying the wire between the two separated tow lines;
c. installing at least a pair of first in-water sensors on the wire for determining the projected coordinates for a positioning on the wire, wherein each first in-water sensor is:
   (i) embedded in the wire;
   (ii) positioned adjacent or on one of the plurality of nodes on the wire;
   (iii) proximate to the wire;
   (iv) on a buoy towed from the wire; or
   (v) combinations thereof;
d. using the pair of first in-water sensors to transmit first sensor information to a processor in communication with a data storage;
e. using the processor and the first sensor information to determine the projected coordinates for the position on the wire;

f. installing at least a pair of second in-water sensors on the wire, wherein each second in-water sensor is:
  (i) embedded in the wire;
  (ii) attached to the wire; or
  (iii) combinations thereof;
g. using the second in-water sensors to transmit second sensor information to the processor;
h. using the processor, the second sensor information, and an algorithm for computing azimuths to compute a first azimuth tangential to the wire for each second in-water sensor;
i. loading a library of nominal values for third, fourth, or fifth order polynomial coefficients, a library of known distances along the wire, and a library of preset limits into the data storage, wherein the library of known distances along the wire comprises:
  (i) distances to each first in-water sensor;
  (ii) distances to each second in-water sensor;
  (iii) distances to each of the plurality of nodes;
  (iv) distances to a location along the wire; or
  (v) combinations thereof;
j. using the projected coordinates from the first in-water sensors and a bearing equation to compute a bearing between the first in-water sensors;
k. using the bearing, the first sensor information, the second sensor information, and a first rotation algorithm to reorient the projected coordinates of the first in-water sensors to local x-y coordinates, forming a local x-y coordinate system;
l. using a second rotation algorithm and the bearing to rotate the azimuths tangential to the wire from the second in-water sensors to reoriented azimuths tangential to the wire into the local x-y coordinate system;
m. using the processor to construct a third, fourth, or fifth order polynomial algorithm of the wire in using:
  (i) nominal values from the library of nominal values for the third, fourth, or fifth order polynomial coefficients;
  (ii) the local x-y coordinates of the first in-water sensors; and
  (iii) at least one distance along the wire from the library of known distances along the wire;
n. using the processor to compute a second azimuth tangential to the wire at each second in-water sensor using the third, fourth, or fifth order polynomial algorithm;
o. using the processor to compute a difference between the computed second azimuths tangential to the wire with the reoriented azimuths tangential to the wire, thereby forming a residual;
p. updating the library of nominal values for third, fourth, or fifth order polynomial coefficients by using the processor to perform a least squares technique using the residual;
q. constructing an updated third, fourth, or fifth order polynomial algorithm of the wire using the processor, wherein the processor uses:
  (i) updated nominal values from the library of nominal values for third, fourth, or fifth order polynomial coefficients;
  (ii) the local x-y coordinates of the first in-water sensors; and
  (iii) at least one distance along the wire from the library of known distances along the wire;
r. using the processor to compute an updated azimuth tangential to the wire at each second in-water sensor;
s. using the processor to compute an updated difference between the computed second azimuths tangential to the wire with the reoriented azimuths tangential to the wire until the residual is within a preset limit of the library of preset limits;
t. using the processor to calculate a pair of local x-y coordinates for at least one of the plurality of nodes on the wire; and
u. using the processor, the bearing, and a third rotation algorithm to rotate the pair of local x-y coordinates from the local x-y coordinate system to the projected x-y coordinate system.

2. The computer implemented method of claim **1**, further comprising:
a. installing a third in-water sensor on each of the plurality of nodes, each of the first in-water sensors, and each of the second in-water sensors, wherein each third in-water sensor is in communication with the processor, and wherein each third in-water sensor is a depth sensor; and
b. transmitting a water depth to the processor from each third in-water sensor for each of the plurality of nodes, each of the first in-water sensors, and each of the second in-water sensors.

3. The computer implemented method of claim **2**, further comprising using the water depths for each of the plurality of nodes to modify the library of known distances along the wire.

4. The computer implemented method of claim **1**, further comprising determining the position on the wire using the first in-water sensors, wherein the first in-water sensors are:
a. global positioning system sensors;
b. laser sensors;
c. acoustic sensors; or
d. combinations thereof.

5. The computer implemented method of claim **1**, further connecting the processor with a network for communication to a client device remote to the processor.

6. The computer implemented method of claim **1**, further comprising computing the projected coordinates in real-time as the floating vessel traverses over a near surface geological formation.

7. The computer implemented method of claim **1**, further comprising constructing a real-time display of the wire.

8. The computer implemented method of claim **7**, wherein the real-time display further comprises: a depth profile of the wire and streamers on the wire, separations between nodes of the plurality of nodes, compass data, depth data, the polynomial coefficients, event information, or combinations thereof.

9. The computer implemented method of claim **7**, wherein the wire comprises at least one streamer connected to at least one of the plurality of nodes, at least one hydrophone connected to at least one of the plurality of nodes, or combinations thereof for collecting seismic data of a near surface geological formation.

10. The computer implemented method of claim **9**, further comprising identifying a location of one of the streamers, one of the hydrophones, or combinations thereof in-real time using the real-time display, and transmitting an alarm when one of the identified locations moves outside of one of the preset limits.

11. The computer implemented method of claim **1**, wherein the wire comprises a seismic hydrophone array disposed thereon.

12. The computer implemented method of claim **1**, further comprising creating a trend analysis over time using the third, fourth, or fifth order polynomial algorithm, wherein the trend analysis over time is a plot of distances between nodes of the plurality of node versus time.

13. The computer implemented method of claim 1, further comprising creating a trend analysis event-by-event using the third, fourth, or fifth order polynomial algorithm, wherein the trend analysis event-by-event is a plot of distances between nodes of the plurality of node versus events.

14. The computer implemented method of claim 1, further comprising using the processor to create a log file containing: the local x-y coordinates, the projected coordinates of the projected coordinate system, events, time stamps, or combinations thereof.

15. The computer implemented method of claim 1, further comprising receiving a time stamp with the sensor information.

16. A computer implemented method for determining projected coordinates in a projected coordinate system for at least one node on a wire having a plurality of nodes, wherein the computer implemented method comprises executing the following steps by a processor:

a. determining projected coordinates for positions for sensors of a first plurality of in-water sensors on a wire from a plurality of a first sensor information sent from the first plurality of sensors;

b. computing a first azimuth tangential from a plurality of second sensor information sent from a second plurality of in-water sensors on the wire, and an algorithm for computing azimuths;

c. computing a bearing between the first plurality of first in-water sensors using the projected coordinates and a bearing equation;

d. reorienting the projected coordinates of the first in-water sensors to local x-y coordinates, forming a local x-y coordinate system;

e. reorienting the azimuths tangential to the wire into the local x-y coordinate system; and

f. constructing a third, fourth, or fifth order polynomial algorithm of the wire in using:

(i) nominal values from a library of nominal values for the third, fourth, or fifth order polynomial coefficients;

(ii) the local x-y coordinates of the first plurality of in-water sensors; and

(iii) at least one distance along the wire from a library of known distances along the wire.

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